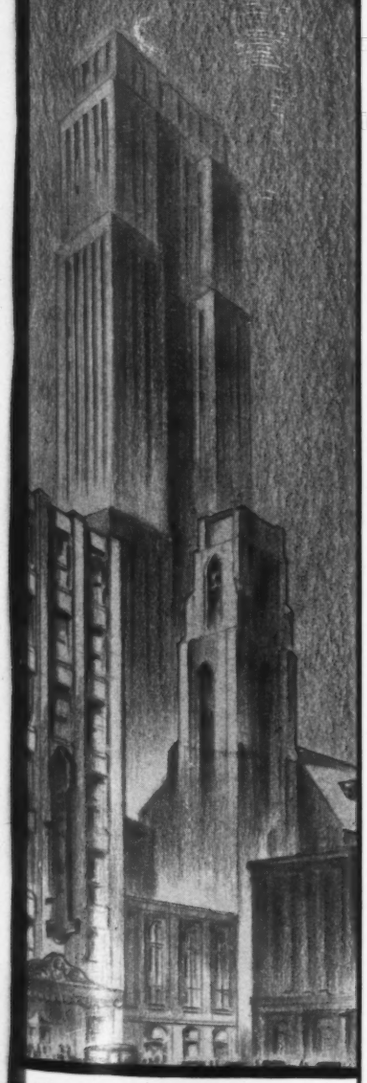
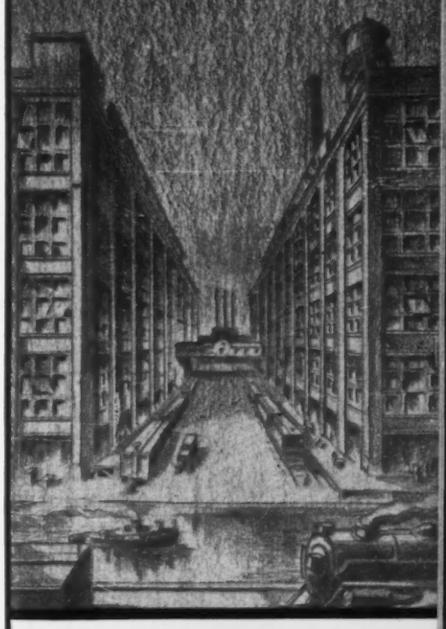
The DECEMBER, 1931

Heating · Piping and Air Conditioning





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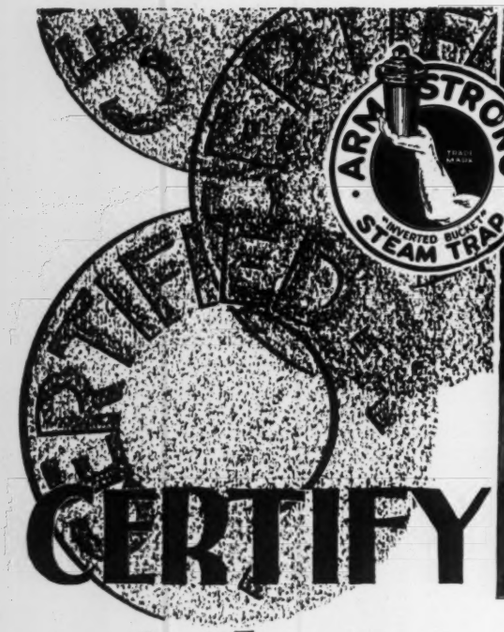
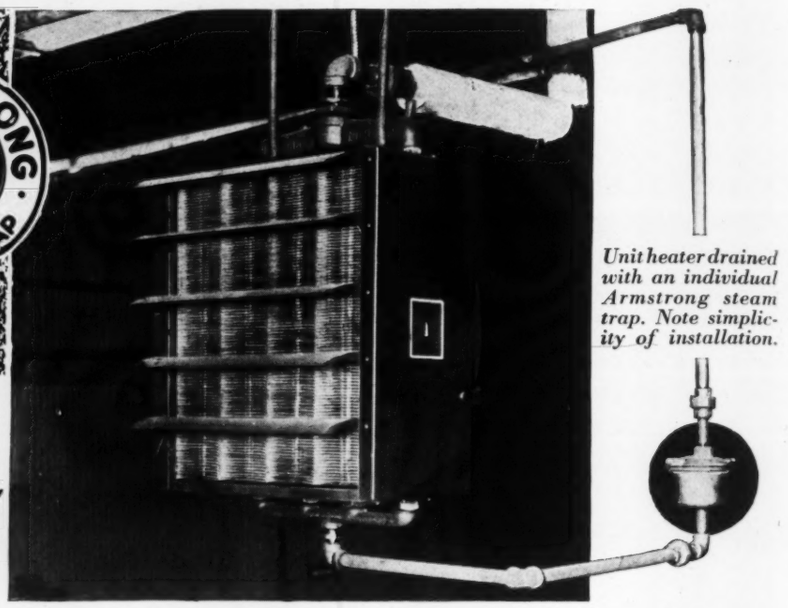




Unit heater drained with an individual Armstrong steam trap. Note simplicity of installation.

unit heater performance with ARMSTRONG Steam Traps

INSTALLATION of Armstrong Inverted-Bucket steam traps offers heating engineers the surest way of "certifying" satisfactory performance of unit heaters.

Armstrong traps automatically drain condensate and discharge entrained air and gases without loss of live steam, thus keeping the heaters up to full efficiency at all times. Backed-up condensate and trapped air cannot impair heat transfer and cut down the capacity of the heater below that for which it is installed.

The popularity of Armstrong traps and the fact that they are widely recommended by unit heater manufacturers and heating engineers result from these desirable features:

—impossibility of air-binding.

—no clogging from oil, scum or sediment. The trap is self-scrubbing.

—small and compact enough to be supported by connecting pipes. All working parts inside.

—greater capacity in pounds of water discharged than most traps of much larger size.

—chrome steel valves which eliminate wire-drawing and valve scoring.

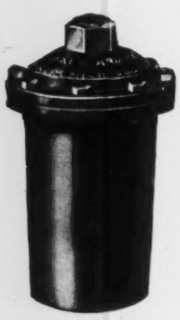
—the trap is always water sealed against steam leakage.

—comparatively low costs.

—made by a company that has specialized on traps alone for 20 years and which pioneered the inverted-bucket principle.

—serviced by a nation-wide organization.

—made in sizes and types for low as well as high pressure, also for superheated or saturated steam.



No. 2 Armstrong Inverted-Bucket steam trap widely used for draining unit heaters.

No. 30 Armstrong trap, also in popular use on unit heater applications.

These advantages mean maximum performance and satisfaction from unit heaters equipped with Armstrong steam traps. Remember to specify Armstrongs for your next unit heater job.

We are glad to cooperate with heating contractors and engineers in determining the proper layouts and trap sizes on heating installations. Booklet giving trapping data sent on request.

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The EDITOR'S PAGE

Heating · Piping and Air Conditioning

C. T. Baker, consulting engineer, writes us regarding Vern O. Knudsen's article "How Sound Is Controlled" as follows:

"I have read the article and consider it one of the finest I ever saw on the subject. I feel that you and the author have contributed valuable data to industry. I am indeed glad to have this for my files."

Prof. Knudsen's paper was published in the October, 1931, HEATING, PIPING AND AIR CONDITIONING and starts on page 815.

Savings of 45 per cent in power to operate an industrial air conditioning plant are achieved by a method of intermittent control which is described fully in an article in this issue. The system conditions the aquatone press room of Edward Stern & Company, Inc., in Philadelphia.

Charles S. Leopold, consulting engineer and one of HEATING, PIPING AND AIR CONDITIONING'S contributing editors, wrote this important article, one of a series now running which demonstrates how economies can be effected in the design, installation and operation of heating, piping and air conditioning equipment.

Last month A. W. Loomis told how the cost of compressed air was cut to the minimum by proper design and layout of an extensive air piping system. Future articles in this related group will cover other matters of vital importance to the heating, the piping, and the air conditioning engineer. Don't miss any of them!

In the back advertising section of this issue is published the index for the January to December, 1931, issues. Following our usual method, the index is composed of a brief, yet thorough, synopsis of each article that has appeared this year. These synopses are then arranged under several easy-to-find heads.

It is felt that this method will aid the reader in preserving a card, or other, file on the particular subjects in which he is primarily interested, as selected synopses can be copied for filing if desired. Also, by scanning through the index, a good idea of what each article contains can be had with a minimum of effort; this eliminates the time wasted in referring to particular subjects only to find them discussed in a manner entirely too sketchy for use, as is so often the case with the conventional alphabetical style of indexing.

Of course, we are at all times anxious to receive suggestions for improving the method of indexing articles, or regarding methods of utilizing the present form of indexing to its fullest advantage.

F. E. Wertheim writes: "As usual, the November issue of HEATING, PIPING AND AIR CONDITIONING is beautifully gotten up and filled with essential information concerning the very latest practice. Arthur McCutchan's article will require some careful study; the piping engineer is fortunate when such articles are presented, as they enable him to learn the methods used in analyzing

difficult and utterly new work in piping design."

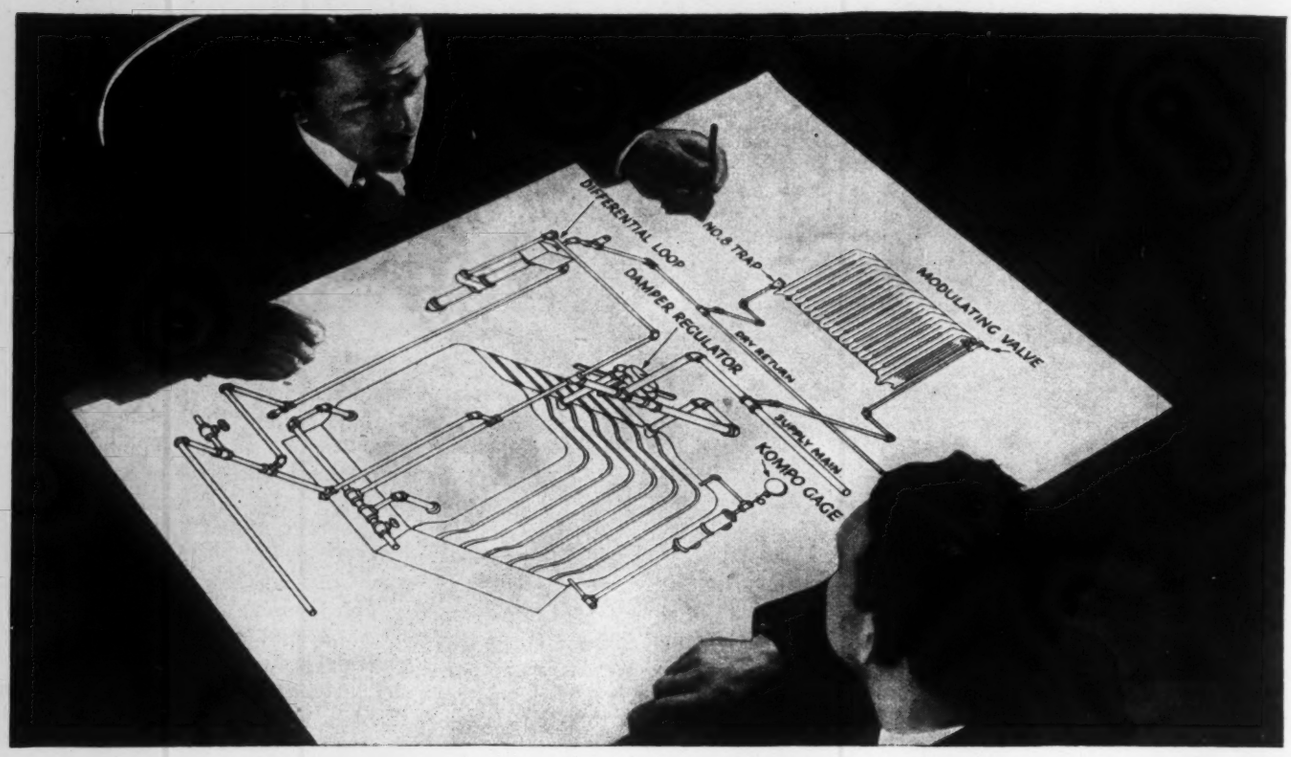
Although we're modest almost to the ultimate in most things, we forget all when it comes to H.P.&A.C.; Henry G. Schaefer — who writes those short, practical articles that are full of helpful ideas — says: "The lay-out of my article in your November number is astonishingly attractive."

And, as the cigarette ads say, "No money was paid for these testimonials."

Variety is the spice of life, so we are told—if this be true, the girl that opens our mail should find existence very interesting. We've received letters addressed to "Heating Ventilating and Piping," "The Heating and Plumbing Contractors," "Heating, Pumping and Air Conditioning," "1900 Prairie Avenue," "Air Conditioning Company," and others too numerous to remember.

We don't mind it, just so the letter gets to us eventually—and, as the "U. S. Mail must go through," the post office department is very efficient in this respect. But we do like to have you—when writing or talking about our articles or advertisements—remember that you **saw** them in HEATING, PIPING AND AIR CONDITIONING. Our name is a little longer than the average, we know; it was chosen after weeks of careful consideration to indicate exactly our editorial interests.

Gentlemen, this introduction is over. Turn over a page and begin reading HEATING, PIPING AND AIR CONDITIONING!



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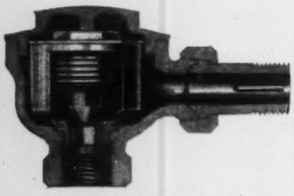
Automatically delivering ample, *flexible* heat on only ounces of steam pressure



Two big features distinguish the new No. 8A Hoffman Traps: (1) Hydro formed Bellows Thermostat (2) Valve pin, seat and thermostat combined in a single unit—quickly replaceable and interchangeable.

No other single decision, in planning a home, can be responsible for as much solid satisfaction, or as much discomfort, as the choice of a heating system.

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Hoffman Controlled Heat—a vapor-vacuum system—offers all these requisites. Yet it consists of only five simple units. On each radiator a No. 7 Hoffman Modulating Valve gives the flexibility—*the room by room temperature control*—for which this system is noted. A finger's touch on the Modulating Valve lever regulates any radiator to the heat output desired—without effect on other rooms.

Full radiator efficiency is assured by the No. 8A Hoffman Trap. Its thermostat operates within a very narrow temperature range, enabling the valve to pass air and condensation upon slight drops in temperature, but without loss of steam.

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Since Hoffman Controlled Heat operates on only ounces of steam pressure, additional savings in fuel are made. The Kompo Gage on the boiler, which indicates vapor pressure or shows whether plant is operating under vacuum conditions, eliminates all guess work from efficient firing and the Differential Loop positively prevents water from leaving the boiler even though abnormally high pressures are developed.

To any boiler or radiators, whether fired by oil, gas or coal, the simple equipment of Hoffman Controlled Heat may be added. When properly installed, it will be guaranteed for many years by its maker.

Full information about Hoffman Controlled Heat, Hoffman Venting Valves, and Hoffman Economy Pumps may be found in Sweet's Catalog. Or write direct to us. Hoffman Specialty Company, Inc., Dept. IG 33, Waterbury, Conn.

To homes, apartments, hotels or office buildings, the comfort and economy of Hoffman Controlled Heat may be added.

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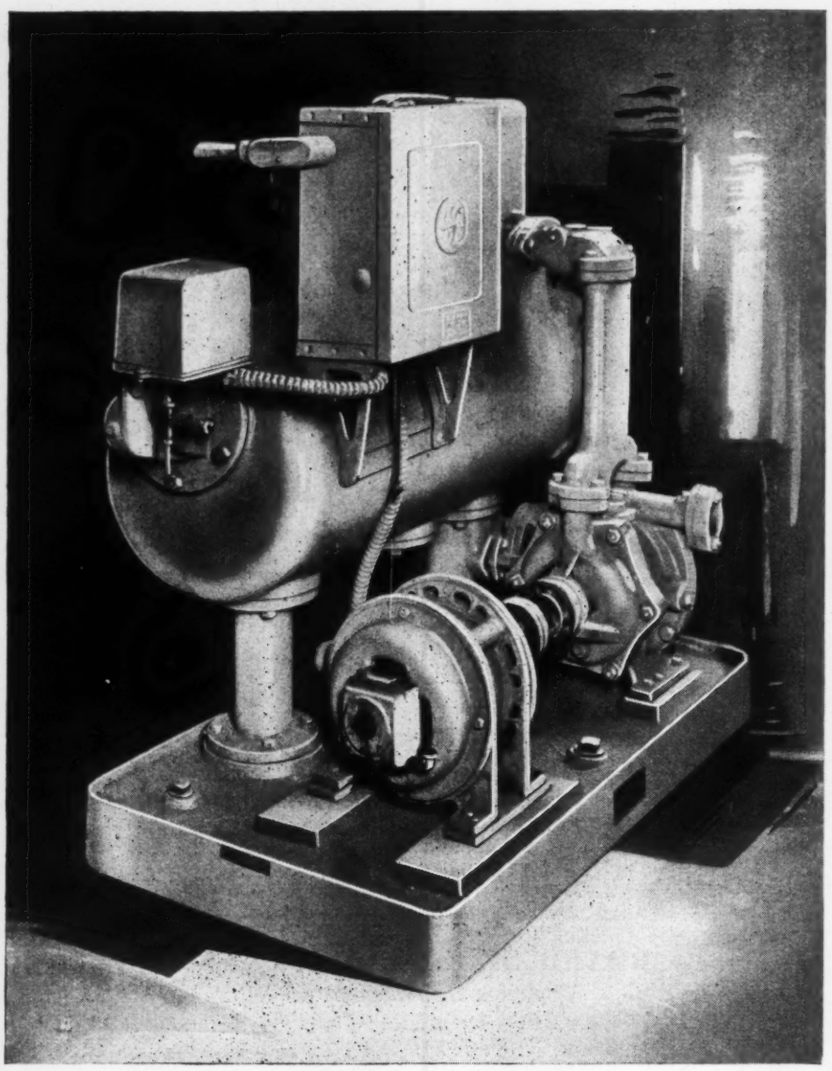
This Pump's combined Air and Water capacity *is easily determined*



DETERMINING the combined air and water capacity of a vacuum heating pump should be as simple as adding 2 and 2. The natural assumption would be that this capacity is the pump's maximum air capacity plus its maximum water capacity. But this is true only of the Jennings Heating Pump.

Two separate units comprise a Jennings Vacuum Heating Pump. One pumps only water, the other only air. Each is designed for maximum efficiency. Neither unit handles the fluid of the other. Air capacity is unaffected by the volume of water being pumped. Water capacity remains constant when air is being handled.

The extra capacity gained permits a Jennings Pump to handle peak loads readily. It assures low operating costs by providing more work from less horsepower.

Jennings Vacuum Heating Pumps are furnished in capacities of 4 to 400 g. p. m. of water and 3 to 171 cu. ft. per min. of air. For serving up to 300,000 sq. ft. equivalent direct radiation. Write for Bulletin 85.

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Jennings Pumps

Heating · Piping and Air Conditioning

Vol. III December, 1931 No. 12

45% Power Saving Made by Intermittent Control of Central Station Type Air Conditioning System

By Charles S. Leopold*

By operating this industrial air conditioning plant intermittently, savings in kilowatt-hours per year in excess of 45 per cent are made, in addition to savings due to reduced consumption of water and steam. The method of control for such operation is explained clearly and typical charts show the results that have been obtained with the system.

IN A NUMBER of industries where air conditioning is required, the period of operation of the machinery in the air conditioned room may be but nine hours of the twenty-four, whereas the demand for proper atmospheric conditions may be continuous due to the necessity of keeping the process materials at a constant moisture content.

Reasons for Intermittent Operation

Since the air conditioning apparatus is designed to meet the combined peaks of occupancy, heat, moisture and power, constant operation during the night, when the total heat from these sources is a minimum, may be wasteful. Fans and pumps work at full load as long as they are in service. Refrigerating machinery, if designed for constant operation, operates at low efficiency under light loads which makes it impossible to realize the full power saving of the lesser tonnage required. If the refrigeration has provision for storage there is still a loss as, in operating an air conditioning unit at a low percentage of capacity, it is usually necessary to permit more air to pass through the dehumidifier than is actually necessary to maintain required temperatures. This results in a corresponding drop of temperature which must be compensated for by the addition of heat. In addition, the heat dissipated by all of the motors of the air conditioning system must be absorbed.

It can be seen that if apparatus can be used intermittently at full capacity, economies should result. This article deals with a solution of this problem in

*Consulting engineer, Philadelphia, Pa.

the *aquatone*[1] press room of the printing plant of Edward Stern & Co., Inc., Philadelphia.

Paper Stretch Must Be Controlled

The general advantage of air conditioning in a press room will not be discussed at this time although the incidental savings in press time more than pay for the complete cost of this system. The particular requirement of the *aquatone* process is that once the gelatin plate has been prepared, it is not possible to shift the individual impressions making up the total

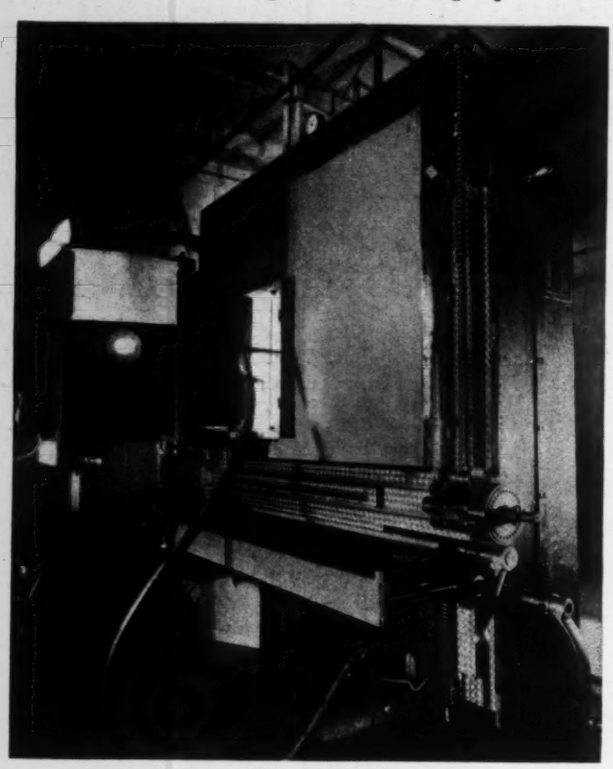


FIG. 1—"STEP AND REPEAT" MACHINE

sheet, as is possible in letter press work. For this reason, should there be any paper stretch between successive color impressions, there is no way in which the pressman can make even approximately satisfactory corrections. The solution of the problem is, obviously, accurate control of paper stretch, which means accurate control of relative humidity.

45% Selected as Proper Relative Humidity

The relative humidity selected as most advantageous was 45 per cent. In summer the dry bulb was calculated for 80 F. Constant temperature was considered desirable. Reference to Fig. 7 indicates the desirability for humidities between 45 and 55 per cent. The percentage change in stretch and shrinkage at this point is small for a comparatively wide range in relative humidity. A 10 per cent increase in relative humidity at 45 per cent results in a paper stretch of approximately 10 per cent of that occurring when the humidity is raised from 65 to 75. This chart represents the "with-grain" and "cross-grain" results on a sample of paper tested by the Bureau of Standards. Results will vary somewhat with the type of paper used. The curve characteristics of most printing papers, however, will be found to be fairly consistent.

Air Conditioning System Standard Save for Control

The press room is in use approximately nine hours of the twenty-four, leaving fifteen hours, mostly at night, when the heat gains, due to sun exposure, people and machinery, are all extremely low. The press room conditioning equipment is shown in Figs. 3 and 4, and a plan of the room is shown in Fig. 5. The design of the system varies from the standard only in the method of control. Briefly, the air conditioning unit is of a standard type, with the exception that a return air damper has been added, in addition to the customary fresh air, dehumidifier and by-pass dampers. The fans handle approximately 10,000 c.f.m. of air; refrigeration is obtained from a 28-ton ammonia compressor operating in conjunction with a Udell cooler (modification of baudelot coils) and a 2,000-gal. storage tank. This refrigerating apparatus is shown in Fig. 6. In addition to the above equipment, a small, oil-fired boiler provides steam for operation during the spring, summer and fall months.

Operation of the Refrigerating Control System

The entire control system was designed to conform with the requirements of intermittent operation. The refrigerating machine is completely automatic as regards the control of water, and ammonia gas and liquid. The operation is as follows:

A thermostat in the water storage tank starts and

---

[1] Aquatone printing differs from the average method in that it is accomplished by the gelatin off-set process. Briefly, a zinc plate slightly larger than the maximum size sheet which the press can handle is prepared with a thin coating of gelatin and sensitized with a bichromate salt. A negative is made by the ordinary photographic process, through a fine screen (usually 200 line). This negative is then printed on the sensitized gelatin covered zinc plate. Where it is desired to duplicate the image on the gelatin plate, it is placed in a machine known as the "step and repeat," shown in Fig. 1. On this machine a negative is held in a vacuum printing frame and moved to its required position by means of the micrometer adjustments shown in the upper left and lower right hand corners. This machine has an accuracy of 1/1,000-in. After development, the gelatin film is found to have the property of absorbing water in those areas not affected by light and to repel water where the light has penetrated the negative. The ink used on the press is of a greasy constituency so that it in turn will be repelled by the water and adhere only to the gelatin on those surfaces affected by light.

In practice, the plate is placed around the upper cylinder of the off-set press, as shown in Fig. 2. As it rotates, it alternately contacts a water roller and an ink roller. The ink from the gelatin plate is in turn deposited on a rubber blanket which covers the lower roller. The paper in passing through the press picks up its ink from this rubber blanket and does not come into contact with the gelatin surface. Excellent reproduction is possible by this process on mat or rough surface papers, with a 200-line screen.

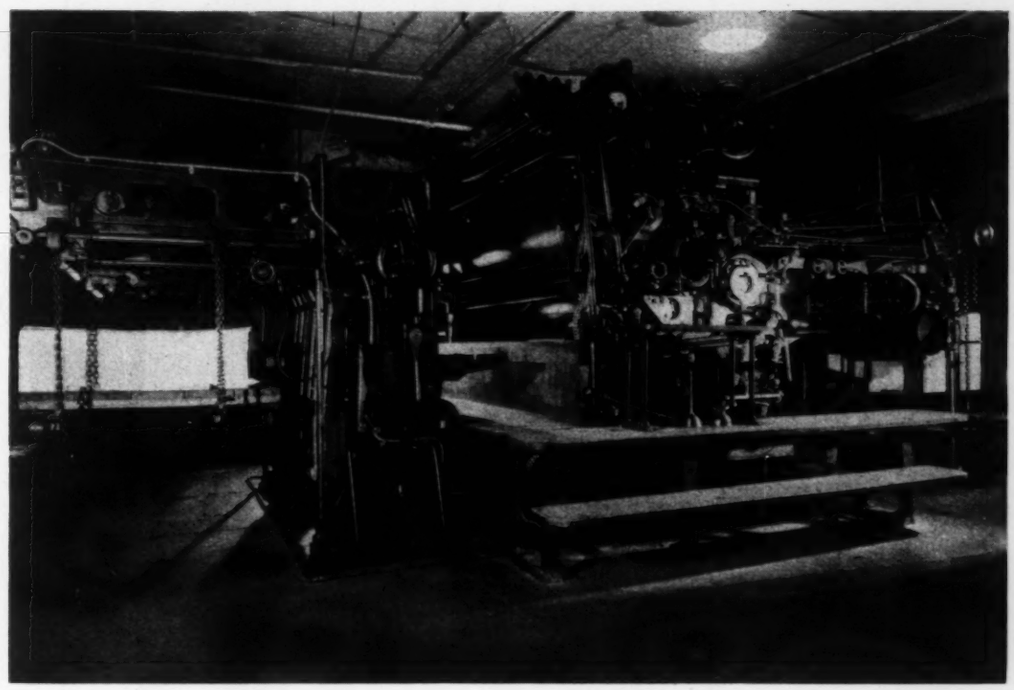


FIG. 2—OFF-SET PRESS

stops the circulating pump of the Udell cooler. In the pump discharge line there is an orifice of proper size to build sufficient pressure to trip a mercury switch. This switch—in turn—starts the ammonia compressor motor. It is thus impossible to start the compressor without a full flow of water over the evaporator. This method of control was adopted for safety.

The refrigerating controls are of standard type. This method of control provides a reserve of cold water for the use of the conditioning apparatus, and the compressor, therefore, operates intermittently at peak efficiency. The pump shown in the foreground of Fig. 6 delivers water from the storage tank in the basement to the three-way valve on the air conditioning unit located on the second floor.

FIG. 3—SOUTH-EAST CORNER OF PRESS ROOM

The Air Conditioning Control Arrangement

In the selection of the control system for air conditioning, it was realized that it would be inadvisable to locate the thermostats on the unit proper as the temperatures obtained during the periods of shut down would cause wide fluctuations in conditions when the unit was restarted. It was decided to control by means of a room thermostat and room humidostat. The location of this apparatus, together with the recording wet and dry bulb thermometer, is shown in Fig. 3. With the rapid air change in the room this method of control has proved entirely satisfactory.

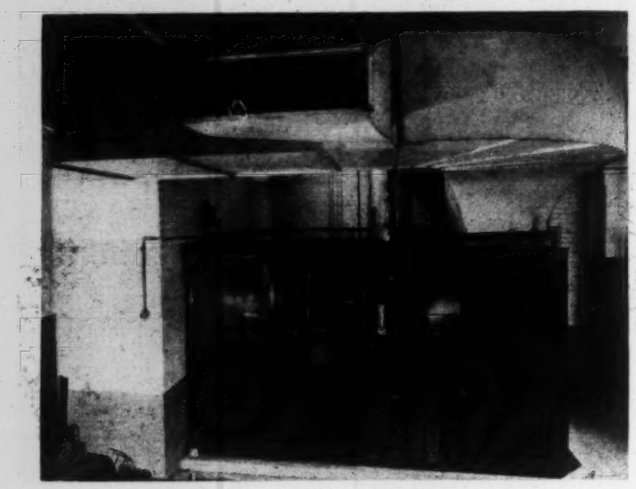


FIG. 4—NORTHEAST CORNER OF PRESS ROOM

The pneumatic portion of the control system is standard with the exception of the addition of an electro-pneumatically operated fresh air damper, which closes whenever the fan is idle, and a pressure-operated electrical switch which starts the oil burner shortly before steam is required, either by the reheater or the water heating coil in the humidifier.

Program Clock Times Intermittent Operation

The timing of the intermittent operation is accomplished by a program clock. A device designed primarily for the control of oil burners in apartment houses was used for this purpose. It consists, briefly, of a synchronous motor-driven clock, connected by a ratchet and pawl motion to a cylinder with three rows of pins in the periphery. At one point opposite each row of pins there is an electrical contact. Since the cylinder is moved by a ratchet mechanism, the contact is of the approved make-and-break type. Holes are drilled at intervals corresponding to fifteen minutes so that by proper placing of the pins, any program can be selected for a period of twenty-four hours. Since there are three rows of pins, three programs may be set up and selected at will by closing the corresponding switch. The motors intermittently controlled are the fan, dehumidifier pump, and cold water pump in the basement. The control of refrigeration is automatic and independent as previously described. If it is desired to supersede the program by constant operation, it is necessary only to throw the switch shown on the face of the column in Fig. 4.

The apparatus was put in operation during the winter and various programs were tried. It was found that 15-min. operation and 45-min. shut down kept the variation in conditions within extremely narrow

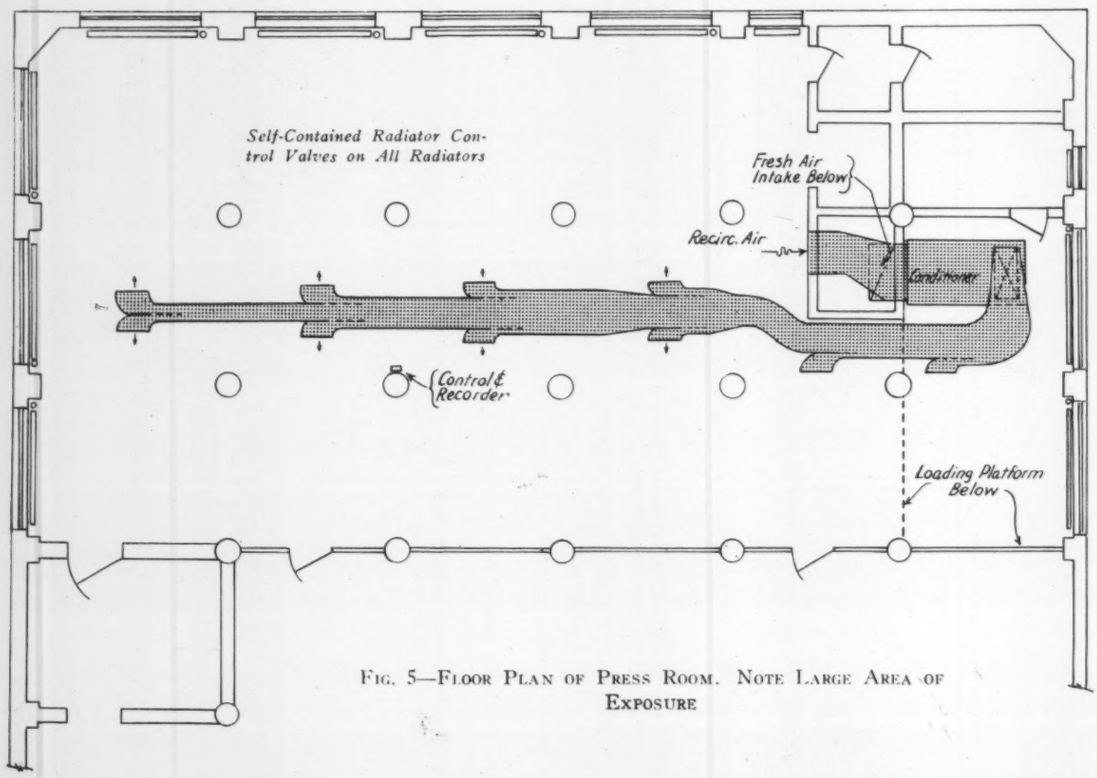


FIG. 5—FLOOR PLAN OF PRESS ROOM. NOTE LARGE AREA OF EXPOSURE

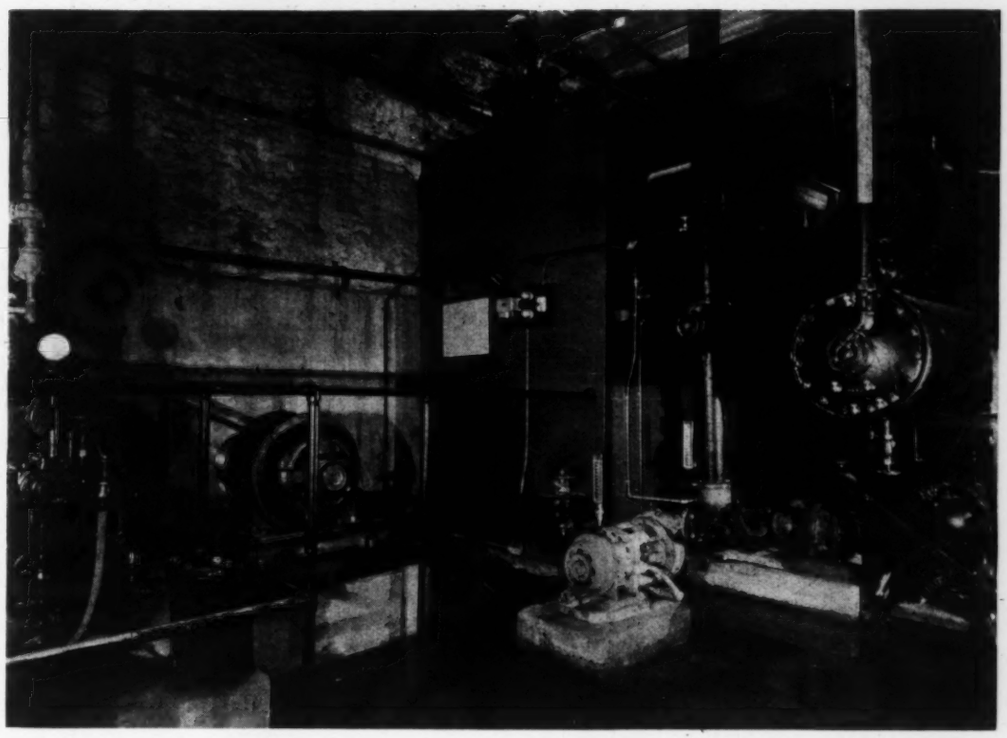


FIG. 6—EVAPORATOR WATER PUMP AT RIGHT. COLD WATER CIRCULATING PUMP IN THE FOREGROUND. UDELL EVAPORATOR LOCATED DIRECTLY ABOVE THE TANK, ALL WITHIN THE CORK AND WOOD ENCLOSURE

limits. This period of operation also proved to be satisfactory for summer.

Charts Show Conditions Maintained with Intermittent Operation

The chart shown in Fig. 11 was started at approximately 11:30 a. m. on a Saturday. Shortly thereafter the plant was placed on intermittent operation, which continued over the week-end until 7:15 a. m. Monday, at which time the plant was placed on constant operation. With constant operation the control is exceptionally close. The average relative humidity under intermittent control was 4 per cent higher than under constant control which, in the range the plant is operating, is negligible as regards paper stretch.

The chart shown in Fig. 12 was started 7:00 a. m. July 27 with constant control but with the steam boiler shut down. The day was extremely hot, the temperature reaching 96 F at 3:00 p.m., and with a high outside wet bulb. The chart shows that although the inside temperature varied, the relative humidity was comparatively constant. At 2:00 p. m. the steam was turned on and continued for the remainder of the operation of the chart. The results obtained without steam were not entirely satisfactory even on this hot day and would have been less desirable with the lesser heat gain at night. The intermittent operation at night resulted in an increased humidity of 5 per cent. At 7:30 the following morning constant operation was started and at 5:00 p. m. the system was again placed on intermittent control.

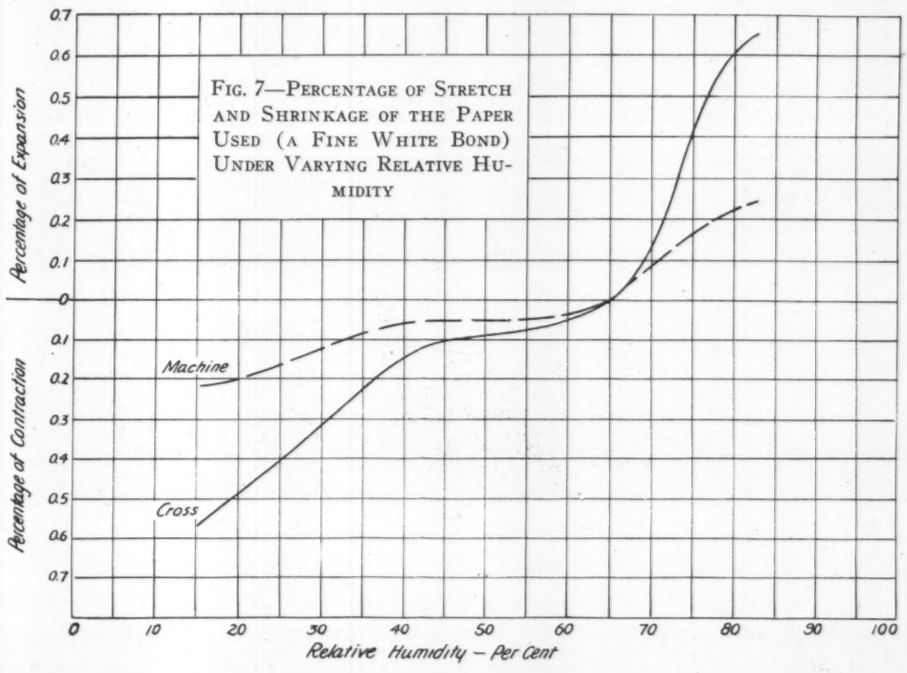


FIG. 7—PERCENTAGE OF STRETCH AND SHRINKAGE OF THE PAPER USED (A FINE WHITE BOND) UNDER VARYING RELATIVE HUMIDITY

The service recorder chart, shown in Fig. 8, ran from 9:30 a. m., July 27, until 9:30 a. m., July 28, and shows the period of operation of the refrigerating machine. The

compressor operated 169 min. of the total of 780 min. between 6:00 p. m. and 7:00 a. m. This brief period of operation is due primarily to the use of the storage tank and is also affected by the intermittent use of fans, pumps, and the minimizing of the limitations of the by-

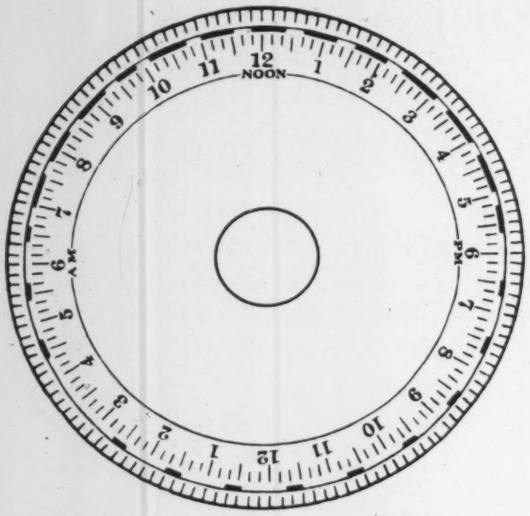


FIG. 8—CHART FOR JULY 27-28, SHOWING INTERMITTENT OPERATION FOR OFF PEAK SERVICE

pass damper, as previously described. Since this is the case, the saving in refrigerating machine power, due to intermittent air conditioning control, could only be determined by a parallel night run with constant operation of the conditioning unit.

Power Savings with Intermittent Control

This run is shown by the service recorder chart for August 14 in Fig. 10. For constant operation during the daytime, the use of refrigeration was 38 min. per hr., which is approximately the same as shown on the chart for July 28. However, on August 14, with the plant running on constant operation during the entire 24-hr. period, it was found, by comparison, that the saving by intermittent control in the off-peak hours proved to be 60 per cent and the saving in total kilowatt-hours used for refrigeration was 40 per cent. The motors affected were the compressor (30 hp.) and the evaporator water pump (1 hp.). The

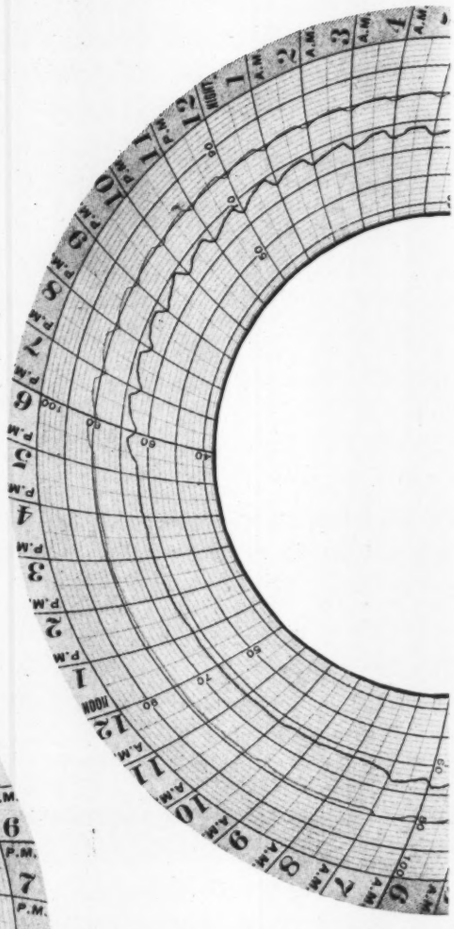
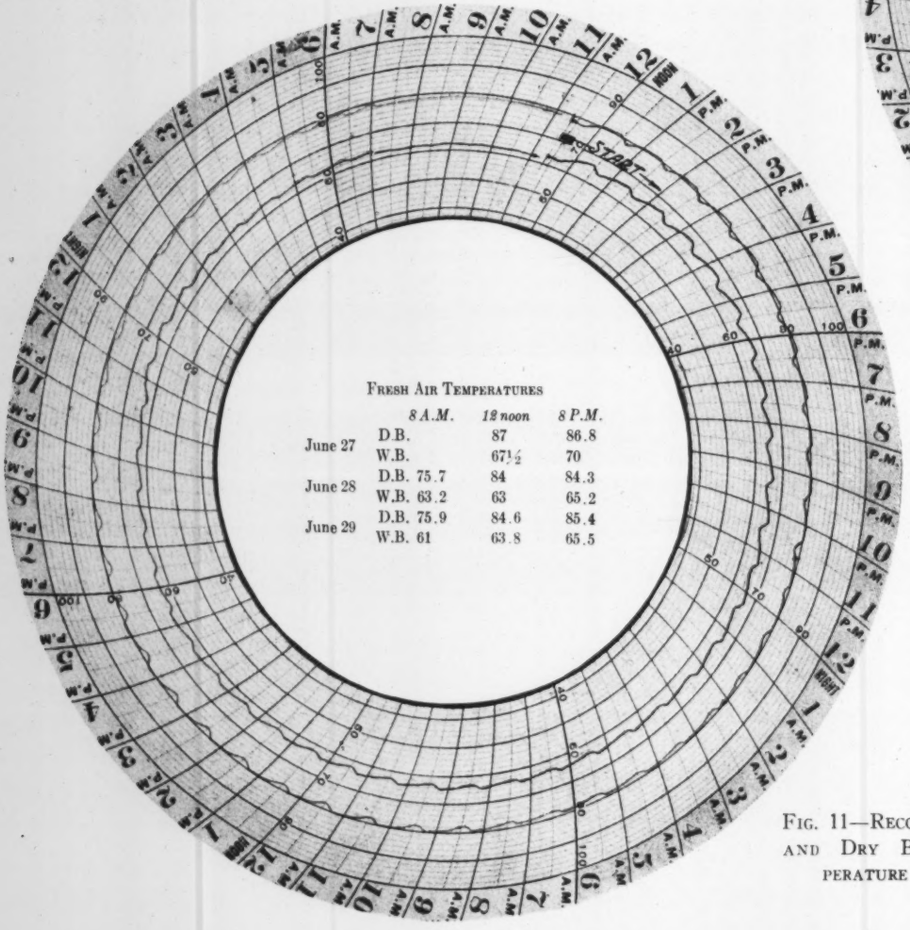


FIG. 9—RECORDING TEMPERATURE CHART OPERATION



FRESH AIR TEMPERATURES

		8 A.M.	12 noon	8 P.M.
June 27	D.B.	87	86.8	
	W.B.	67½	70	
June 28	D.B. 75.7	84	84.3	
	W.B. 63.2	63	65.2	
June 29	D.B. 75.9	84.6	85.4	
	W.B. 61	63.8	65.5	

FIG. 11—RECORDING WET AND DRY BULB TEMPERATURE CHART

FRESH AIR

	8 A.M.
July 22	D.B. 71.2
	W.B. 65.2
July 23	D.B. 78
	W.B. 70.6
July 24	D.B. 73.7
	W.B. 68

actual demand is approximately 28 kw.

The power saving for the other motors of the system can be calculated. These units are the fan (5 hp.), dehumidifier pump (5 hp.), cold water pump (3 hp.), a total of 13 hp. The combined demand of the motors is approximately 10 kw. The plant operates constantly for approximately 52 hours a week and 25 per cent of the remaining 116 hours, or a saving of 87 hours. The power savings are, therefore:

For air conditioning motors.....52 per cent.
For refrigerating motors.....40 per cent.

The savings in kilowatt-hours per year will therefore be in excess of 45 per cent and there will be an additional saving due to the reduced consumption of water and steam.

Conclusions

The experience with this system demonstrates that satisfactory conditions may be obtained by the intermittent operation of a central station air conditioning system during off-peak hours. With a period of operation of 15 min. on and 45 min. off, the kilowatt-hour saving was over 45 per cent.

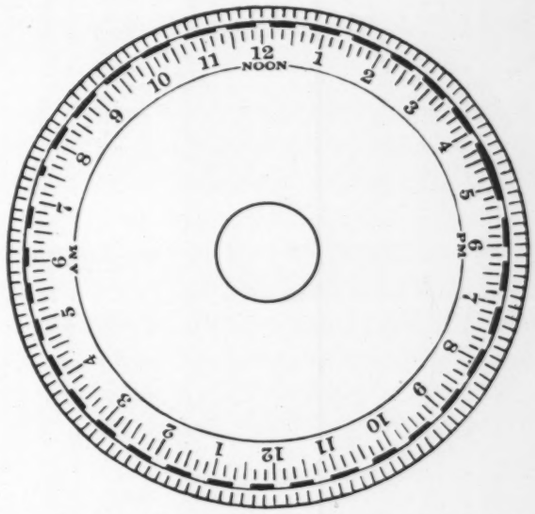
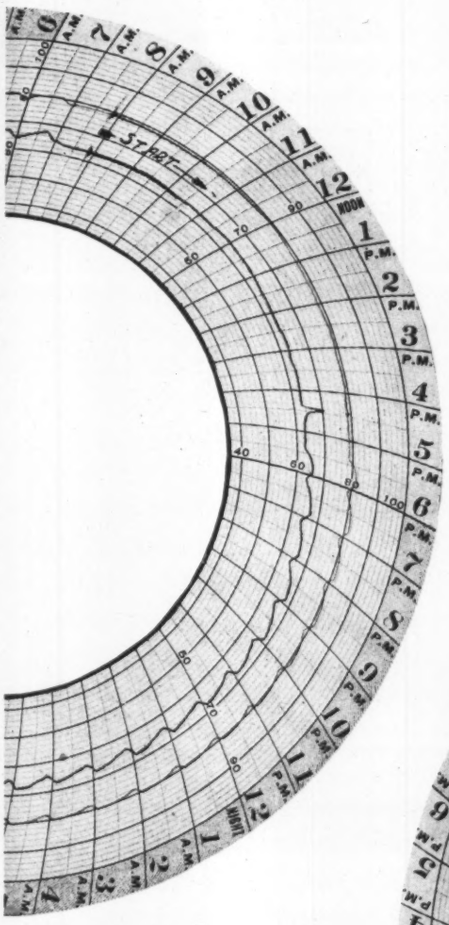


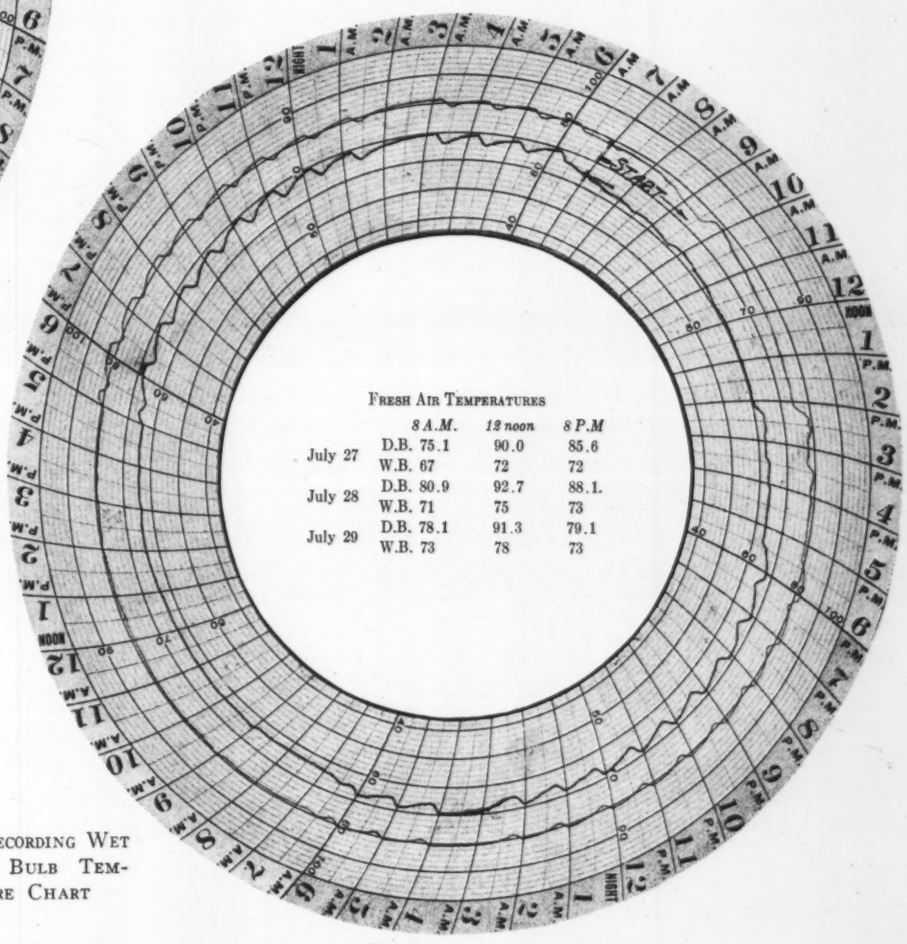
FIG. 10—CHART FOR AUGUST 14, SHOWING RESULTS OF CONSTANT OPERATION FOR OFF PEAK SERVICE



WET AND DRY BULB FOR NORMAL WEEKDAY OF SYSTEM

TEMPERATURES

12 noon	*8 P.M.*
81.3	79.3
68	71
85.9	82.3
70.3	72
80.3	
71	



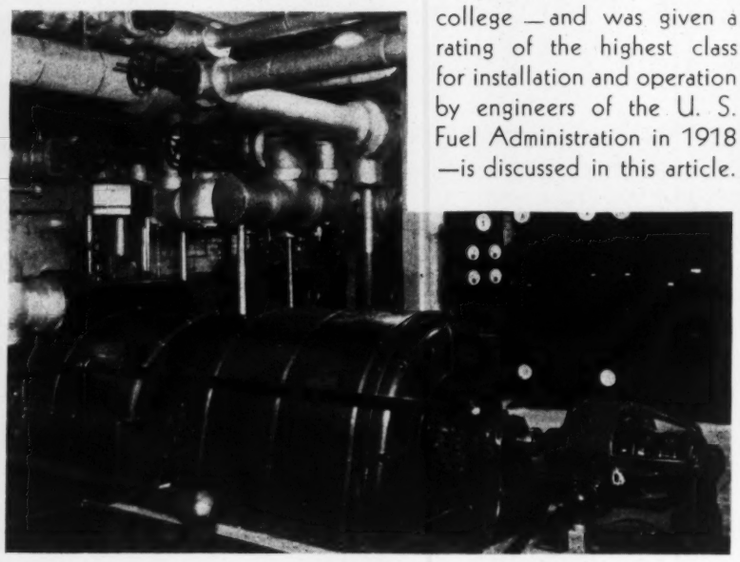
FRESH AIR TEMPERATURES

		8 A.M.	*12 noon*	*8 P.M*
July 27	D.B.	75.1	90.0	85.6
	W.B.	67	72	72
July 28	D.B.	80.9	92.7	88.1.
	W.B.	71	75	73
July 29	D.B.	78.1	91.3	79.1
	W.B.	73	78	73

FIG. 12—RECORDING WET AND DRY BULB TEMPERATURE CHART

Turbine Cuts Steam Waste in Heating and Power Plant » »

How a surplus of exhaust steam was utilized in order to prevent wastage and excessive fuel consumption is told in detail and the growth of the plant which serves Berea college — and was given a rating of the highest class for installation and operation by engineers of the U. S. Fuel Administration in 1918 —is discussed in this article.



THE 625-KVA. TURBINE-DRIVEN GENERATOR, SHOWING THE MAJOR PIPING DETAILS. BEHIND THE SWINGING PANEL AT THE LEFT OF THE SWITCHBOARD THE 12-IN. EXHAUST LINE IS SEEN. THE STEAM SUPPLY TO THE TURBINE MAY BE SEEN AT THE LEFT OF THE ILLUSTRATION

By D. D. Kimball*

BEREA COLLEGE, Berea, Ky., was established in 1855. During its early history it provided education to white and colored youth, especially those from the mountainous back counties of Kentucky, Tennessee, Virginia, and West Virginia; later a separate institution was provided for the colored youth because of an act of the state legislature.

Central Plant Installed in 1900

About 1900 the college plant proper consisted of approximately twelve buildings. At this time it was decided to install a central heating and electric plant to provide heat and electricity for the new buildings. The boiler plant consisted of two 60-in. diameter, brick set, horizontal return tubular boilers and one 12 in. by 12 in. slide valve engine, belt-connected to a 110-220 volt d.c. generator. This equipment served a group of three nearby buildings erected at this time.

Central Plant Service Extended

In 1909 it was decided that the central plant service should be extended to all of the college buildings; this involved the development of the central plant upon quite a new scale, with adequate provisions for future growth of the college. A careful study was undertaken, having for its purpose the most accurate possible forecasting of the extent and area of growth of the college within a period of twenty years. A central site was then selected for a new power house which was to provide for the boiler plant, ample coal storage facilities, an electric generating plant, and an ice making plant.

The power house and a chimney 100 ft. high with an internal diameter of 60 in. were erected. In the boiler room were installed two new 72-in. diameter, brick set, horizontal return tubular boilers. Space

* Kimball and Cucci, consulting engineers, New York City.

was provided for the later installation of four more such boilers, two of which were later installed. Two 100-kva. turbine driven, electric generators were also installed and alternating current was substituted for direct current.

Remote Buildings Supplied with 40-50 Lb. Steam

Underground steam and return mains connecting all of the college buildings to the central boiler plant were laid in sectional tile conduits. To the group of buildings on what was then the main college campus, at one end of which the power plant was placed, steam was supplied at a pressure of 5-lb. maximum to permit the use of the exhaust steam from the generating plant. To those buildings more remote from the power house, steam was supplied at 40 to 50 lb., first, because in some of these more remote buildings this higher pressure was required for cooking purposes in the kitchens, but especially because long, large, low pressure lines were more costly than seemed justified.

In general, separate connections were made to each building heating system and to a hot water storage tank containing steam coils. In each case where the steam is delivered at the higher pressure, reducing valves—with three valved by-passes,—were installed for both the heating and hot water service.

This plant then provided heat for fifteen buildings and electric current for the same buildings together with power for the laundry and for the college shops, lighting for the college grounds and lighting for a number of houses. In 1913 a story was added to the power house building at one end and a college laundry was installed on a level over the electric and ice making plants.

Plant Now Sells Power

In 1917 the college purchased a city franchise under which the college plant furnished all lighting for the streets and sold electric current commercially. 564 customers, not counting college accounts, are now thus supplied. In 1930 electric current to the extent of 1,113,900 kw-hr. was produced in this plant.

Two New Boilers Installed in 1923

Gradually the college plant increased and the services of the central plant were extended. About 1923, a marked extension of the college plant was undertaken, a growth very materially exceeding the provisions which fourteen years previously had been visioned as very ample for a period of twenty years. A new chimney 8 ft. in diameter and 150 ft. high was erected, and two 300-hp. water tube boilers designed to operate at 160-lb. were installed, being supplemented by four of the horizontal, fire tube boilers which were left in position. The new boilers were equipped with multiple retort stokers. The installation of the boilers necessitated the raising of the boiler house roof about eight feet.

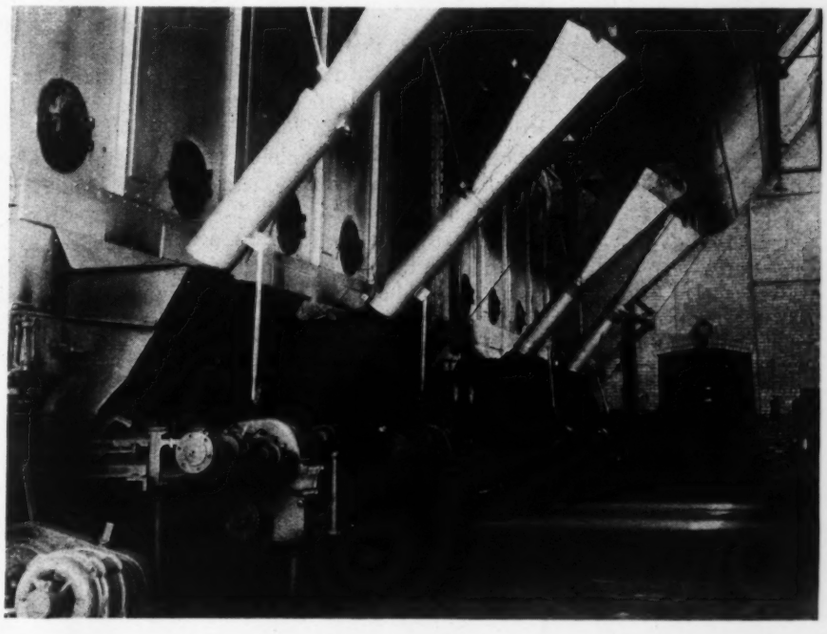
In 1926 the original boiler feed pumps and feed water heater were replaced with similar equipment of a much greater capacity, a portion of the original boiler room being taken to provide space for new apparatus.

Two More in 1927

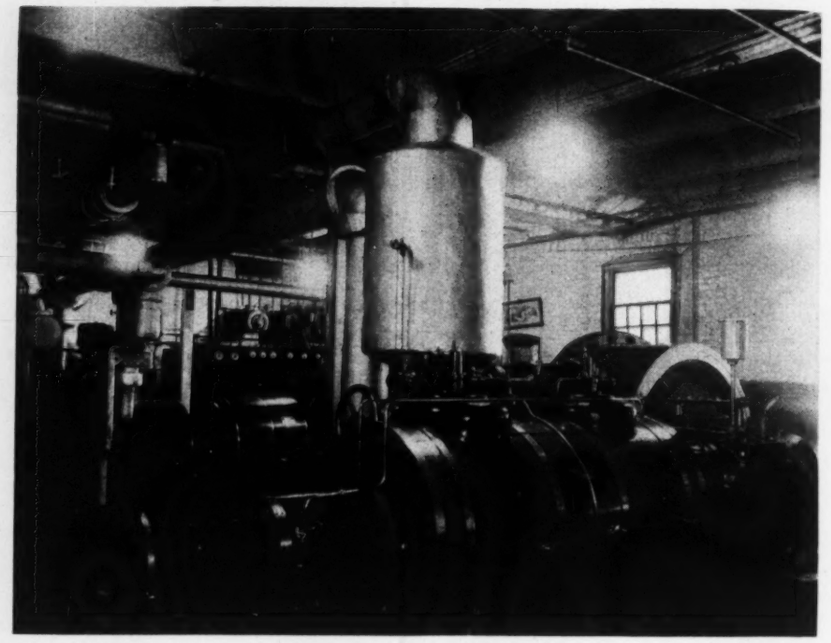
By 1927 the construction of new buildings demanded further boiler capacity. The remaining horizontal return tubular boilers were then removed and two more of the 300-hp. boilers (of the same type as installed in 1923) were installed, with stokers as before. A complete coal handling equipment, with an overhead coal bunker, was also installed at this time. A year later, a 300-kva. electric generator directly connected to a uniflow engine was necessary to care for the increasing electric load.

Growing Power Demands Cause Exhaust Steam Waste

By 1930 the electric load had so increased that



INTERIOR OF THE BOILER ROOM, SHOWING THE FOUR 300-HP. BOILERS EQUIPPED WITH HEAVY DUTY AUTOMATIC STOKERS, AND THE SUSPENDED COAL STORAGE BIN



INTERIOR OF THE ENGINE ROOM WITH THE 300-KVA. UNIFLOW ENGINE IN THE FOREGROUND AND THE 625-KVA. TURBINE DRIVEN GENERATOR BEYOND

additional generating equipment appeared necessary. But during these years of the rapid and "spread-out" growth of the college a serious problem had been developing. In the original conception of the central plant the future growth of the college had been envisioned as occurring largely in the vicinity of the power plant. Through the purchase of additional property many of the new buildings had been erected at considerable distances from the power house and had been connected to the steam lines operating at 40- to 50-lb. steam pressure. But these new buildings were also supplied with electric current by the generating plant, with the result that the quantity of exhaust steam produced was beginning to exceed the requirements of the buildings in which low pressure exhaust steam could be used and the capacity of the underground service mains originally installed for the utilization of exhaust steam at a maximum pressure of 5 lb. The result was a considerable wastage of exhaust steam and with this an increase in the cost of producing electric current, and a wasteful consumption of fuel. The only possible opportunity for the use of this surplus exhaust steam was in those buildings served with steam at 50 lb., but this back pressure seemed to be a serious handicap on a prime mover.

Installation of Turbine Conserves the Exhaust Steam

The problem was finally solved by the installation of a 625-kva. turbine driven generator, the turbine being designed to operate with an initial steam pressure of 150 lb. and against a back pressure up to 50 lb. The exhaust steam, upon leaving the turbine generator, is passed through one or both of two pressure reducing valves, one serving the 40-50-lb. heating lines, the other serving the 5-lb. heating lines. In the non-heating season this exhaust steam may be used for heating water used in the laundry insofar as possible, the balance being discharged outboard at atmospheric pressure. Only when all of the 50-lb. pressure exhaust steam can be thus used is this turbine operated at this high back pressure. At other times the uniflow engine generator is used or the turbine generator is operated at a back pressure of 4 lb. by a simple adjustment of the atmospheric relief valve. During the non-heating season either generator, preferably the engine generator, is operated without any back pressure whatever.

At the present time this plant serves a connected heating load equivalent to 230,000 sq. ft. of radiation and serves more than eighty buildings, in addition to a connected electric load of 500 kw. In 1930, 10,315 tons of nut and slack bituminous coal were used in this plant.

Auxiliary Equipment

In the auxiliary equipment of this plant there are included a water treatment plant and a fire protection system with a large central fire pump. Boiler plant auxiliaries include a venturi feed water meter, coal measuring devices; CO_2, draft, feed water temperature, flue gas temperature, steam pressure and electric recorders.

At the present time additional forced draft equipment is to be installed and two additional boilers are to be installed in the near future.

Plant Has High Rating for Efficient Operation

An hourly record of plant operating data is maintained and the efficiency of plant operation is calculated daily, and frequently for each fire-room shift. An overall boiler plant efficiency of approximately seventy per cent is generally maintained by constant and careful checking of the operating data and methods. Usually, the boilers are operated at about 200 per cent of normal rating.

In 1918 the engineers of the *U. S. Fuel Administration* gave to this plant a rating of the highest class for installation and operation, a rating equalled by only slightly over 1 per cent of 85,000 plants inspected throughout the United States, and slightly more than double that of the average of all of the plants inspected.

Editor's Note: From the inception of the first plant to the present time, the development, construction, installation, and operation of these plants have been under the immediate supervision of George G. Dick, chief engineer for the college, with D. D. Kimball as consulting and designing engineer.

Installing a 3,400-Ft. Overhead Steam Line

In this article the author describes the installation of a 3,400-ft. overhead welded pipe line which furnishes steam for heating express cars when loading and unloading, and cars in a repair yard. The line has a capacity of 6,530 lb. per hr. at 150 lb. gage and 100 F superheat

By L. C. Winkelhaus*

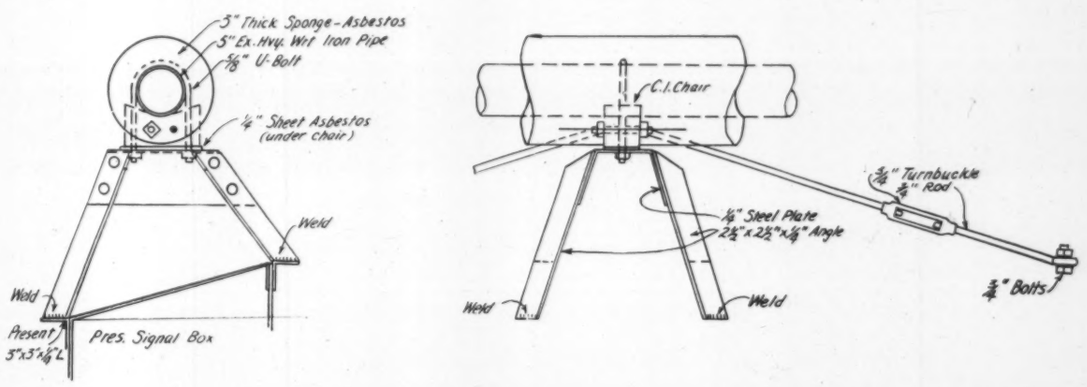
EARLY this spring, the Chicago & North Western Railway Company completed, and placed in operation, a large railway express terminal for handling express commodities from train to truck and vice versa. The plant is located along the westward main lines of the railway, and just outside of its Madison street passenger station in Chicago.

The house tracks at the express terminal are of such length and arrangement as to permit the placing of a maximum of 45 express cars for loading or unloading; it is essential that these cars be heated during the winter months. Adjacent to the express terminal, the railway company constructed a car repair yard with trackage for 20 cars, either for repair work, or "holdovers;" these cars may require heating. In connection with the car repair yard, various buildings were provided for locker rooms, store rooms, waste renovating plant, etc.; all of which had to be accommodated with heat. In addition, the heating of the express building itself entered into the problem.

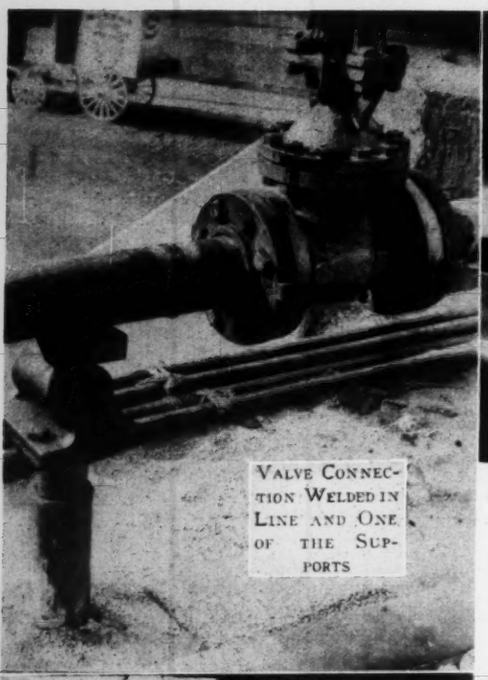
It would appear that the construction of a central heating plant was the correct solution; or, that sufficient boiler capacity be provided in the express building to meet all the heat requirements involved. However, the express company was obligated to provide heat for its building and desired a low pressure plant. The railway company's engineers thought it advisable to accomplish car heating with high pressure steam.

At the passenger terminal, a matter of 2,500 ft. away, the railway company already operated a modern power plant. Investigation disclosed that this plant had ample boiler capacity for the passenger station requirements, and could take on the additional load of the railway company's requirements at the express terminal, but did not have sufficient capacity to accommodate the express company's needs. The final decision was to provide a low pressure boiler plant in

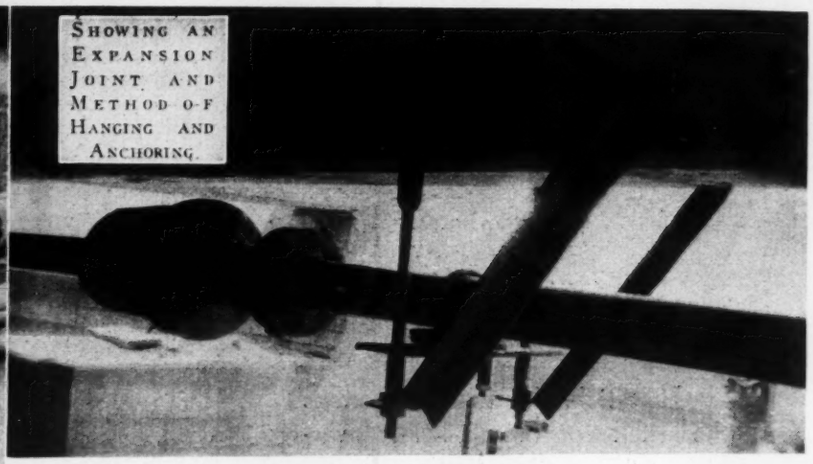
* Assistant engineer, Chicago & North Western Railway Company, Chicago, Ill.



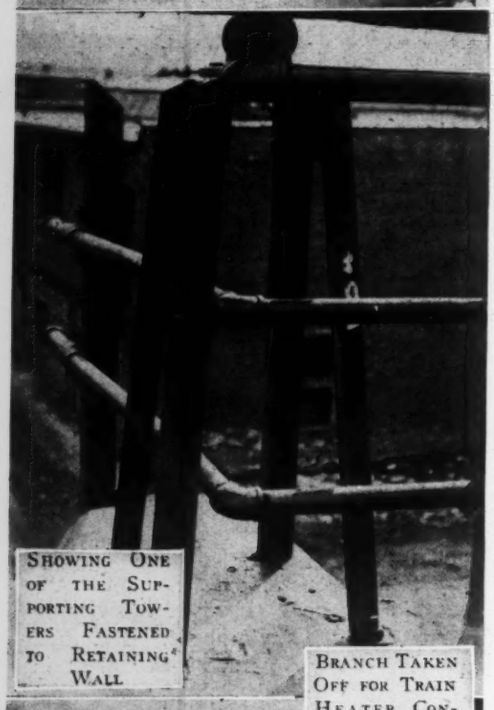
ON THE STEEL BRIDGES, EACH OF THE STEEL PIPE TOWERS IS WELDED TO THE BRIDGE STRUCTURE



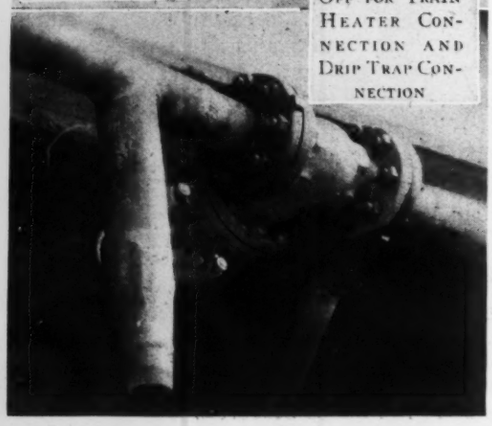
VALVE CONNECTION WELDED IN LINE AND ONE OF THE SUPPORTS



SHOWING AN EXPANSION JOINT AND METHOD OF HANGING AND ANCHORING



SHOWING ONE OF THE SUPPORTING TOWERS FASTENED TO RETAINING WALL



BRANCH TAKEN OFF FOR TRAIN HEATER CONNECTION AND DRIP TRAP CONNECTION

the express terminal for heating the building, and to construct a high pressure steam line from the passenger terminal power plant to the express terminal for heating cars standing at the plant, together with the cars in the repair yard, and for contingent car repair yard facilities. The total length of the overhead pipe line is about 3,400 ft. Condensation is not returned to the boilers.

Estimating Needed Capacity of Line

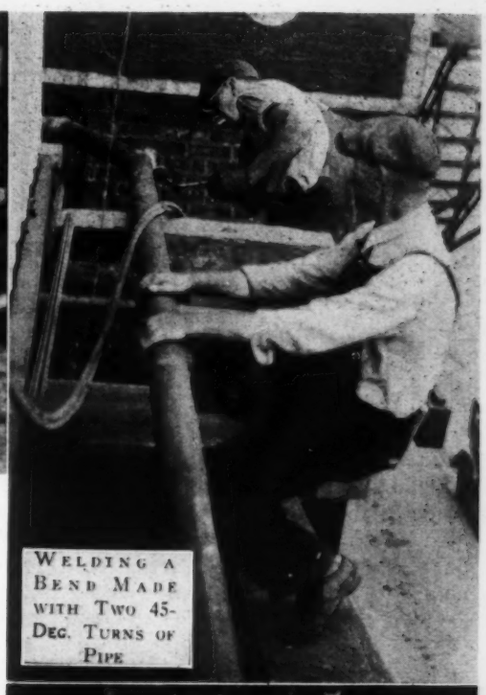
In determining the size of pipe required to give ample supply, the contingent factors were (a) maximum number of cars to be heated at one time; (b) heat requirements for the car repair yard facilities; and (c) loss in pressure. The greatest number of cars possible to place at the platforms is 45, and the total number that might be placed on repair tracks is 20—a total of 65. Each car was assumed to require 265 sq. ft. of radiation, or a total of 17,225 sq. ft., equivalent to 5,775 lb. of steam per hr. An additional 225 lb. of steam per hr. was allotted for heating small buildings, a waste renovating plant, etc.

With a total requirement of 6,000 lb. per hr., a 4-in. pipe was found necessary, which gave a velocity of 3,400 ft. per min. The radiation loss was calculated at 530 lb. per hr., which made the total steam requirement 6,530 lb. per hr., increasing the steam velocity to 3,660 ft. per min. The pressure drop to the first service pipe was calculated to be 48.9 lb., and the total expansion in the entire length of line approximately 7 ft. All figures are based on 150 lb. gage steam pressure, 100 F of superheat, and —10 F outside temperature.

Pipe Sizes Used

The total length of the high pressure pipe line (3,360 ft.) is made up of 640 ft. of 5-in. pipe, 2,370 ft. of 4-in. pipe, and 350 ft. of 3-in. pipe. On leaving the power house, the pipe line is on an ascending grade of 1⅝ in. per hundred feet for the total length of the 5-in. pipe. The end of the 5-in. line is the summit, and the type of bridge structure supporting the tracks at this point was the governing factor in locating the high point. This portion of the pipe line was made

Applying the Sponge Asbestos Covering to the Line


Welding a Bend Made with Two 45-Deg. Turns of Pipe

larger than the calculated size so as to compensate for the loss in net area due to possible condensation returning to the boilers. Passing the high point, or summit, the pipe is reduced to 4 in. for 2,370 ft. and is on a descending grade of 3 in. per hundred feet. Three 2-in. laterals are taken from this line for car heating. Beyond these take-offs, the pipe size is reduced to 3 in. for a distance of 350 ft. to the car repair yard buildings, where a reducing valve is installed to accommodate the normal pressure (15 lb.) for cast iron radiation.

Line Is Welded

All of the pipe is genuine wrought iron with bevelled ends for welding. The welding was done by the railway company's own forces. There were no fittings used on the line, except at the two gate valves and at the expansion joints. Nipples at take-offs, as well as the two reducers, were made in accordance with standard welding practice.

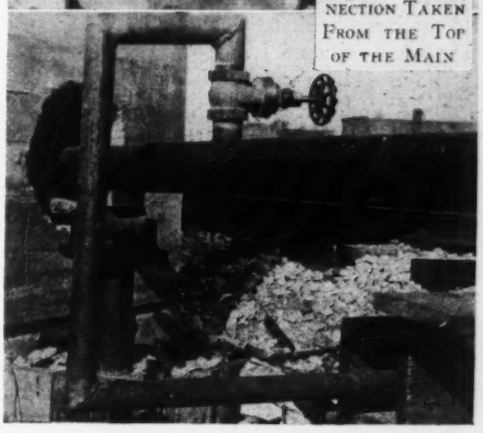
Providing for Expansion

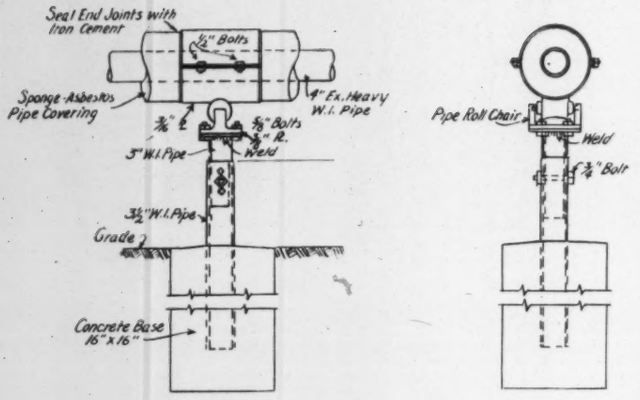
To provide for expansion, ten expansion joints and two expansion loops were inserted in the line. These, together with the off-sets around buildings and in order to follow retaining walls where possible, were considered ample provision for expansion. The pipe was securely anchored at each expansion joint at the adjacent tower. Anchors were similarly placed at each of the expansion loops. The expansion joints are of the externally-guided, single-slip type, with a maximum travel of 8 in. The necessity of remaining on the railway company's right-of-way precluded the use of expansion loops throughout. The loops were used only where the support at the middle of the loop could be placed on the right-of-way.

Supporting the Line

All but approximately 600 ft. of the line is out-of-doors, and is supported on steel towers attached to steel bridges, or bolted to concrete retaining walls. The 600 ft. of pipe line under cover passes through the express terminal, and is hung from overhead floor beams. The towers are made up of four structural steel angles riveted together at the shop with the

Typical Connection Used as Outlet to Train Heating System


A Branch Connection Taken From the Top of the Main



TYPICAL SUPPORT FOR THE PORTIONS OF THE LINE CARRIED OVER EARTH FILLING

necessary connection plates, braces, etc. Each tower is of a different height in order to provide for the grade of the pipe, and they vary in height from 7 ft. 10 in. to 8 in. (made up of a bent plate). The towers on the retaining walls are bolted to the concrete, using ¾ in. by 6 in. standard expansion bolts at each of the four legs. On the steel bridges, each of the four legs of the tower is welded to the bridge structure. Fortunately, in the original construction of the bridges, a structural steel box was provided on the outside of all girders within the pipe line limits, for carrying train signal conduits. Advantage was taken of this box for supporting the outer legs of the pipe line towers.

Bolted to the tops of the towers are the standard cast iron pipe rollers, or, in the case of anchors, special castings are used. Tie rods are of ¾-in. wrought iron with turnbuckles in the middle of the rods. Rods are bolted either to the concrete retaining walls or to bridge steel. The pipe is securely fastened to the towers at points of anchorage with ¾-in. diameter U-bolts directly in contact with the pipe. At all roller supports, a steel band 12 in. wide is placed around the pipe covering to allow for expansion slippage.

A portion of the pipe line is carried over earth filling. Where this is done, a 3½-in. pipe was set up in a concrete base and a 3-in. pipe set inside it, adjusted to proper grade, and bolted in place.

Duplicate Bucket Traps Installed

As considerable condensation was anticipated at the further end of this long steam line, a duplicate set of large bucket traps was installed. Each trap has a capacity of 1,200 gal. per hr. for steam at 150 lb. The condensation is all wasted at this point. At the power house end, an automatic double acting non-return and emergency cut-out valve was installed, together with a bucket trap.

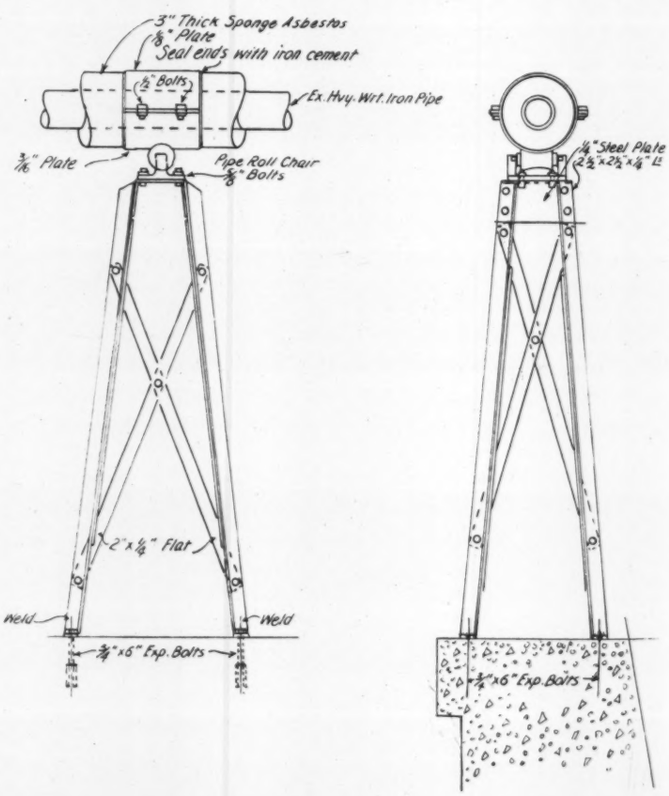
The Pipe Covering

All of the pipe covering is standard asbestos sponge felted sectional insulation; 3 in. thick for the 4- and 5-in. pipe, and 2 in. thick for the 3-in. pipe. Asbestos fiber felt insulating cement was used at all the joints. The pipe insulation exposed to the weather is protected with an asbestos weatherproof jacket; this portion of the covering is wired on with No. 16 copper wire rings at 6 to 8 in. intervals. All horizontal laps are on the side of the pipe and the lap of the weatherproof jacket is turned down to shed all water from the surface. The insulation under cover is protected with an 8-ounce canvas jacket, painted.

After the covering was in place and the entire line was supported on the rollers, it was found that the weight of the covering and pipe, between supports, was more than the crushing resistance of the insulation itself. It was necessary to weld ¾-in. bars cross-wise in the lower half of the steel bands at each roller support, to take the major portion of the load off the insulation.

Testing the Line

A test was made of the pipe line before the covering was placed. Steam was let into the line through



THE TOWERS SUPPORTING THE LINE ARE MADE UP OF FOUR STRUCTURAL STEEL ANGLES RIVETED TOGETHER WITH THE NECESSARY CONNECTION PLATES, BRACES, ETC. THE TOWERS ON THE RETAINING WALL ARE BOLTED TO THE CONCRETE

a 1¼-in. by-pass, rather slowly, to let the pipe warm up gradually, so that any undue expansion, or leaks, might readily be held under control. Marks had previously been made at all expansion joints, anchors, and a few of the roller supports, in order that the movement of the pipe might be noted. After the pipe had become thoroughly warmed, and no leaks found, the full steam pressure of 150 lb. was turned on and allowed to blow out at the further end. While no pressure reading was taken at the outlet, the indications were that there would be ample steam and pressure to meet the requirements.

The railway company, through its purchasing department, purchased all the materials and specialties required for the work. The steel towers were bought completely fabricated and delivered to the site, and erected by the railway company's iron bridge erection crew. The rest of the work was carried out by the regular division forces; inasmuch as all the work was along tracks elevated above the streets, and in close proximity to very busy passenger service this seemed advisable.

The work was carried out under the general supervision of C. T. Dike, chief engineer; the design of the pipe line, expansion joints, and other items pertaining to the steam line itself, was handled under the direction of E. B. Hall, general superintendent of motive power and machinery.

Methods of Supplying Fluid to Hydraulic Press Installations

By F. G. Schranz* and W. L. DeLaney*

There are several different types of systems for supplying water —or other fluid—to hydraulic press installations. This article describes many of them, and is of aid in selecting the system most applicable to the particular case.

AN HYDRAULIC press installation, whether it be a single press, or a battery of presses, is of little value unless an adequate supply of water (or other fluid) is provided at all times. In order to insure uninterrupted service, duplicate units are sometimes installed. This is especially true where the installation is large. The duplication is usually confined to the pumping equipment, as this permits one or more of the pumps to be reconditioned without delay.

In laying out a pumping system, it is desirable to keep the number of pumping units as small as possible and, at the same time, to so select their capacities that the spare or idle units do not necessitate an excessive investment.

Each installation, so far as water supply goes, is a problem by itself. There have been a number of supply systems developed, which are outlined below; one of these will usually be found applicable to the immediate problem. The systems are more or less elastic, with considerable latitude, founded upon individual ideas or preferences.

In addition to the pumps for supplying water at various pressures, there are, at least, two pieces of accessory apparatus, which deserve special mention; namely, an accumulator and an intensifier.

The Accumulator

The accumulator consists of an hydraulic cylinder and ram, either of which may be stationary, so arranged that varying quantities of water are stored at constant pressure. This forms a reservoir from which the fluid may be drawn as required. Its capacity should be sufficient to take care of the maximum instantaneous requirements of the system, plus a reserve of from 10 to 25 per cent. The stationary part of the accumulator is mounted upon a substantial base, while the moving part carries at the top a crosshead, from which is suspended a steel basket on a platform, into or onto which the weights (ballast) are placed to secure the required pressure in the system.

The Intensifier

An intensifier consists of a device for increasing the pressure in a system by means of rams with different diameters. Suppose we have a plunger 12 in. in diameter, working at 1,500 lb. pressure per sq. in. and desire to obtain water at 4,500 lb. per sq. in.; what should the diameter of the high pressure ram be? As the pressures are inversely proportional to the ram areas, we have:

Area of 12-in. ram = 113 sq. in.

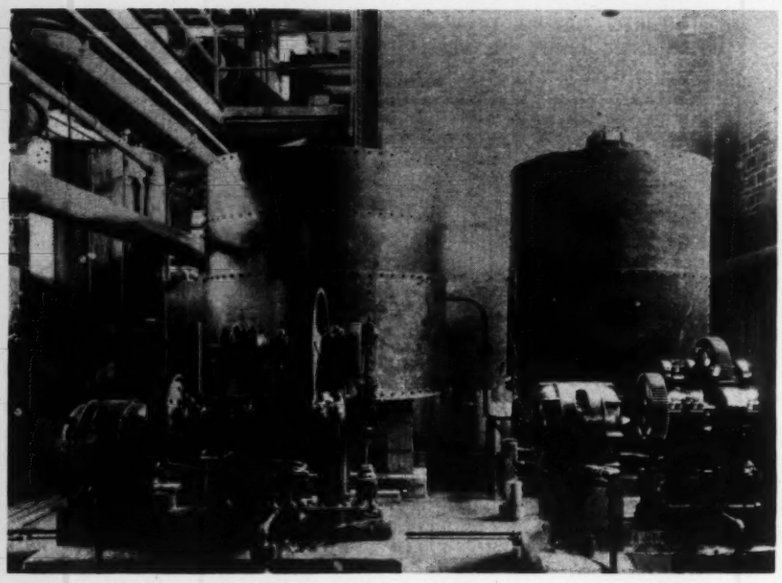
Then $113 : x :: 4{,}500 : 1{,}500$, where x equals area of the ram required.

$$x = \frac{113 \times 1{,}500}{4{,}500} = 34 \text{ sq. in.}$$

and a ram with an area of 34 sq. in. will have a diameter of approximately 6½ in.

Th length of stroke determines its capacity, which is usually stated in cubic inches displacement.

*Baldwin-Southwark Corporation, Philadelphia, Pa.



PUMPING UNIT CONSISTING OF HIGH PRESSURE PUMP AND ACCUMULATOR AND LOW PRESSURE PUMP AND ACCUMULATOR. THE HIGH PRESSURE SET IS AT THE RIGHT AND THE LOW PRESSURE AT THE LEFT. NOTE THEIR RELATIVE SIZES

A simple intensifier has its limitations in practice, due to the fact that it becomes unwieldy in size where large quantities of high pressure water are required.

Type of Pumps

Pumps for high pressure service may be variously classified. The following gives a general idea of the types usually used:

(A) Hand-operated pumps.
  (a) Single pressure.
  (b) Two pressure.
(B) Steam-driven pumps.
  Single cylinder (simplex) single or double acting.
  Two cylinder (duplex) single or double acting.
(C) Motor-or belt-driven.
  Centrifugal (low pressures only).
  Multi-cylinder rotary.
  Vertical triplex (3 single acting cylinders).
  Horizontal duplex (2 double acting cylinders).

The pump discharge may be controlled by means of a throttle valve in the steam line, in case of a steam pump, or by electric limit switches or a by-pass valve when a motor-driven pump is used. The latter permits starting the pump under "no load" conditions, which eliminates the heavy starting current for the motor otherwise required.

Types of Systems

The following systems are used for supplying water (or other fluid) to hydraulic presses.

Single Pressure Systems:

(A) The press is operated directly from the city water main. Excessively large rams and cylinders are required to produce a given tonnage. It is limited to installations where very light tonnage is required, such as riveters for ring gears.

(B) Press operated directly from a hand pump.—This system finds its practical limitations in the quantity of fluid which can be supplied. It is suitable for small straightening presses, arbor presses, forcing presses, etc., where speed is not essential and where occasional usage is made of the equipment.

(C) Press supplied directly from a steam or motor-driven high pressure pump. This system finds wide application in die sinking operations, car wheel and locomotive wheel presses and various forms of forcing and straightening presses, sugar roll presses, etc., and curb (rendering) presses.

This system is limited in speed by the pumping capacity, but conserves power, as the pump load is directly proportional to the resistance met at all times.

(D) Presses supplied directly from a steam or motor-driven high pressure pump, with an accumulator in the discharge line between the pump and presses.

This system is widely used where simplicity of valve control and speed of operation is essential. It is not as economical in operation, so far as power costs go, as a two-pressure system. It has been used almost exclusively in plants producing shell forgings, as not only speed, but also a long power stroke, are requisite. Plants drawing long tubes and bottles, extruding metals, etc., utilize this system.

Multiple Pressure Systems (High and Low Pressures):

(A) The press is supplied direct from a low pressure steam or motor-driven pump through its idle stroke, after which water is supplied from the high pressure steam or motor-driven pump to finish the stroke.

This system is more applicable to a single press installation than where a number are operated on a line, as it does not permit maintaining a constant pressure on those in service where additional press units are put into operation.

The speed of operation is limited to the capacity of the pumping equipment.

(B) Presses supplied by independent high and low pressure system, each with its own accumulator and pumps.

This system finds a wide application where a large number of units are working on a regular cycle, part of which consists of an idle stroke. It permits the use of a small capacity high pressure installation, thereby conserving power, while the low pressure system furnishes an ample supply for the idle stroke, at low cost and at

the same time permits rapid operation through the idle stroke.

For such a system, the pumping capacity may be made sufficient for the average requirements, rather than the maximum, as the accumulator system takes care of the excess demand at any given time.

A variation of this sytem uses a high pressure pump and accumulator, with a low pressure steam pump. Such a system works well on rubber curing systems, where it is necessary to maintain the pressure on the press from the high pressure system for a definite period, while the low pressure pump capacity may be made sufficient to give the desired idle stroke speed.

(C) Press may be supplied from either a single pressure system, or a high and low system, with or without accumulators, and further be provided with an intensifier. The practical limiting feature in this case is, of course, the water requirements at the extra high pressure. If this demand is excessive, the intensifier becomes too large, making its cost excessive.

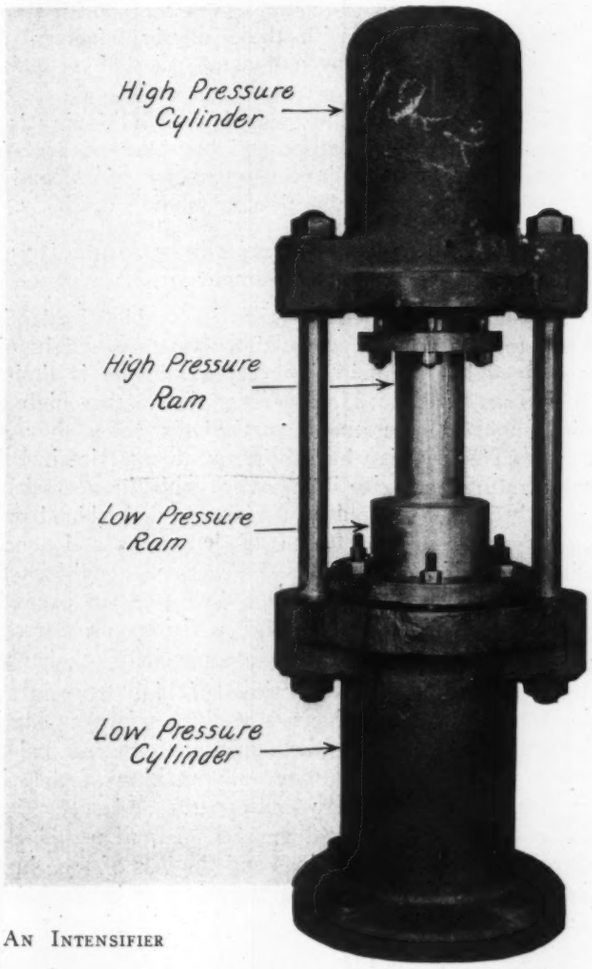
The installation of such a unit is well illustrated in a steam hydraulic forging press, where the cylinder carries the hammer through its idle stroke and the intensifier is used for the final squeeze. It is used similarly for final upsetting operations where the regular system will do the greater part of the work and only a small amount of water is required for the final squeeze, "to fill up the corners" or fill the dies.

(D) Press supplied from an air filling system, with an intensifier.

In this system, low pressure water is supplied from a filling tank, which is connected to an air pressure system of 100 lb. per sq. in., or more. The air pressure is used to force the water into the press cylinder during its idle stroke and also to furnish intensified pressure through an air-water intensifier for the final or working stroke. This system is limited by the intensifier capacity and is not particularly economical, due to the compressed air requirement. It, however, has a special interest where other sources of power are not available and a small number of presses are operated independently.

(E) In order to conserve power, a two-pressure system has been developed. This consists of a centrifugal pumping unit, motor-driven, for supplying low pressure water, with an intensifier for furnishing water for the working stroke. This system necessarily is limited in its power stroke by the capacity of the intensifier.

In order to eliminate this handicap, where several presses are to be supplied for the same unit, a double-type intensifier is utilized, whose action is similar to a steam-driven double-acting pump. This insures a high pressure water supply, depending directly on the demands. This system is applicable to individual and multiple press installations.



An Intensifier

IN NEXT MONTH'S ISSUE—

John Howatt writes on studies of school heating plant operating efficiency in next month's **Heating, Piping and Air Conditioning.** Records have been kept for the past ten years on the operation of the heating and ventilating plants in 400 public school buildings in Chicago, which are under the jurisdiction of Mr. Howatt. His article presents some valuable data from these records and includes suggestions on how to obtain efficient operation.

Ralph E. Phillips and Donald T. Robbins have given a detailed description of the air conditioning system for the Los Angeles stock exchange building in their paper which is to be published next month. Data on the cost of installation of the equipment are presented, in addition to the explanation of the engineering features of the design.

Temple C. Patton has prepared two informative charts which are of aid in selecting the proper amount of insulation to apply to piping and flat surfaces. The charts and his article on this subject will appear in the January number. Three typical cases are considered: (1) One insulation material applied to piping; (2) one insulation material applied to a flat surface, and (3) two insulation materials applied to a flat surface.

(Glance through the index for 1931 which appears in the back advertising section of **this** issue. Note the numerous practical, informative articles which have been published. **Heating, Piping and Air Conditioning's** editorial program for 1932 will be even more intensive.)

The Influence of Atmospheric Conditions on Health and Growth

By C. P. Yaglou*

The Report to the Committee on Growth and Development, White House Conference on Child Health and Protection—Part II—Indoor Atmospheric Conditions.

Air Conditioning

Changes in Composition and Vitiation of Air by Respiratory and Metabolic Processes

Under the artificial conditions of indoor life, the air undergoes certain chemical changes and a vitiation brought about by the occupants themselves. The oxygen content is somewhat reduced, and the carbon dioxide slightly increased by the respiratory processes. Organic matter, which is usually perceived as odors, is given off from the mouth, teeth, skin and clothing, and to some slight extent, perhaps, from the lungs. The temperature of the air is increased by the metabolic processes, and the humidity raised by the moisture emitted from the skin and lungs. Both dust and bacteria content of the air increase.

Contrary to former theories, the usual changes in oxygen and carbon dioxide are of no physiological concern because they are much too small even under the worst conditions. The carbon dioxide in air is often used in ventilation work as an index of odors of human origin, but the information it affords rarely justifies the labor involved in making the observation. Little is known of the identity and physiological effects of the organic matter given off in the process of respiration. The former belief that the discomfort experienced in confined spaces was due to some toxic volatile matter in the expired air is now limited, in the light of numerous researches, to the much less dogmatic view that the presence of such a substance has not been demonstrated. The only fact that does appear certain is that expired and transpired air is odorous and offensive, and it is capable of producing headache, nausea, loss of appetite and a disinclination for physical activity. Experiments have shown that the growth of young guinea pigs is retarded by exposure to odors from decomposing organic matter (*20*).† These reasons alone, whether aesthetic or physiological, are sufficient to warrant adequate ventilation.

A certain portion of the dissemination of disease in confined spaces is caused by the continuous emission of pathogenic bacteria from infected persons. According to the weight of opinion, infections by droplets from coughing and sneezing constitute a limited mode of transmission, in the immediate vicinity of the infected person. Experiments have shown that the mouth spray is a coarse rain which settles down quickly. The contamination is local and the problem is considered to be largely one of contact infection rather than air-borne infection. This view does not dismiss from consideration the whole problem of air-borne infections and its relation to ventilation, as some persons believe. Our present knowledge of infectious diseases and their manifestation is too limited to justify such a broad assumption.

It is now believed that the primary factors in air conditioning, in the absence of any specific contaminating source, are temperature, humidity and air movement. This is quite true, since upon these factors depends the loss of body heat by radiation, conduction, and evaporation. As compared with these physical factors, the chemical factors are, as a general rule, of secondary importance.

The principal object in general air conditioning is to keep down the temperature and humidity of occupied spaces within proper limits, to remove odors, and to prevent stagnation of the air surrounding the body.

Physiological Effects of Temperature, Humidity and Air Movement

Although the human organism is capable of adapting itself to variations in external temperature and humidity, its ability to maintain heat equilibrium is limited. Numerous studies (*21, 22*) have shown that high environmental temperatures, particularly when they are accompanied by high humidities, produce a rise in body temperature, owing to interference with the normal loss of body heat. The pulse rate increases, the blood pressure decreases, and a feeling of depression and general discomfort is experienced. In extreme conditions the metabolism is markedly increased, due to the excessive rise in body temperature, and a vicious cycle results which may finally lead to serious physiological damage.

One of the deleterious effects of high temperatures is that the blood is diverted to the surface capillaries by vasomotor shifts, at the expense of the internal organs. This lowers the tone and nutrition of the vital organs. The victim may lose appetite and suffer from indigestion, headache and general enervation. The alterations in gastric secretions and the loss of tone in the intestinal tract may be the potent factors in the heightened susceptibility to gastro-intestinal disorders in warm atmospheres.

*Assistant Professor of Industrial Hygiene, Harvard School of Public Health. Member of the Committee on Growth and Development, White House Conference on Child Health and Protection.

† See corresponding reference in the bibliography.

Physical work under such conditions is a great effort. Experiments show that men can produce twice as much work at an effective temperature of 70 F as they can at 93 F (*23*). Even a temperature of 75 F with a relative humidity of 50% is capable of reducing appreciably the physical work (*24*).

Moreover, habitual exposure to such abnormal conditions tends to lower the tone of the heat regulating mechanism, and according to Mills (*25*) the function of the adrenal glands is also depressed. This general depression may lead to an inability to respond to later demands for increased activity.

The literature in regard to the action of cold on human beings is very meager. Extreme cold seems to be borne better than extreme heat, probably because the effects of cold are largely mitigated by artificial control. Cold affects the human organism mainly in two ways: (a) through its action on the body as a whole and (b) through its action on the mucous membranes of the upper respiratory tract. Very little exact information is available on this latter action.

Within certain limits, compensation for increased loss of body heat is effected by increased metabolism and decreased peripheral circulation. The rectal temperature often rises upon exposure to cold. The blood pressure increases, but the pulse rate and surface temperatures decrease. In extreme exposures compensation fails. The body temperature falls and the reflex irritability of the spinal cord is markedly affected (*26*). The organism may finally pass into an unconscious condition which ends in death.

Changes in temperature are very significant. A moderate amount of variability in temperature is known to be beneficial to health, comfort, and the performance of physical and mental work. On the other hand, extreme changes in temperature, such as those experienced in passing from a warm room to the cold air out-of-doors, appear to be harmful to the tissues of the nose and throat, particularly in the case of infants and young children.

Experiments show that chilling causes a constriction of the blood vessels of the palate, tonsils and throat, which is accompanied by a fall in the temperature of the tissues. On re-warming, the palate and throat do not always regain their normal temperature and blood supply, and this anaemic condition is believed to play a part in the inception of the common cold and other respiratory disorders.

The effect of humidity upon the organism has been the subject of many studies, discussions and controversies, but much of the problem still remains open. With one or two exceptions, the experiments were too limited in duration, and other conditions were generally so variable as to yield contradictory results. Dry air is known to produce an excessive loss of moisture from the skin and respiratory tract. Owing to the cooling effect of evaporation, higher temperatures are necessary, and this condition may lead to discomfort and lassitude. Moist air, on the other hand, interferes with the normal evaporation of moisture from the skin, and again may cause a feeling of oppression and lassitude, especially when the temperature is also high.

Just what is the optimum range of humidity is a matter of conjecture. There seems to exist a very general opinion, supported by some experimental and statistical data, that warm dry air is less pleasant than air of a moderate humidity, and that it dries up the mucous membranes in such a way as to increase our susceptibility to colds and other respiratory disorders (*13, 27, 28, 29*).

The recent works of Blackfan and Yaglou (*2*) also indicate that a fairly high degree of moisture in

the air is favorable to the health and growth of premature infants.

Air movement also plays an important role in air conditioning, not only because it disperses the envelope of warm and humid air in contact with the body surfaces, but also because it produces a pleasant and stimulating sensation upon the skin.

Measuring Atmospheric Conditions and Their Effects

No single instrument has yet been devised to indicate accurately the suitability of the thermal environment for comfort and health. Two arbitrary methods are used at present for measuring approximately atmospheric conditions and their probable effects on people; (a) the kata thermometer method, and (b) the effective temperature method. The kata thermometer (*30, 31*) is a physical instrument, and

it is used extensively in Great Britain. The American standard is the effective temperature index (*32*). This is a relative index of the degree of warmth or cold felt in response to temperature, humidity and air movement. It combines these three factors into a single value, which is fairly well correlated with physiological

responses to heat and cold. An atmospheric condition is said to have an effective temperature of 65 F, for instance, when it induces a sensation of warmth like that experienced in a saturated atmosphere of 65 F in still air.

When the dry- and wet-bulb temperatures and the rate of air movement are known, the effective temperature can be computed from charts or tables. Fig. 4 shows one of these charts, that which is most commonly used in air conditioning, for persons normally clothed and for sedentary conditions.

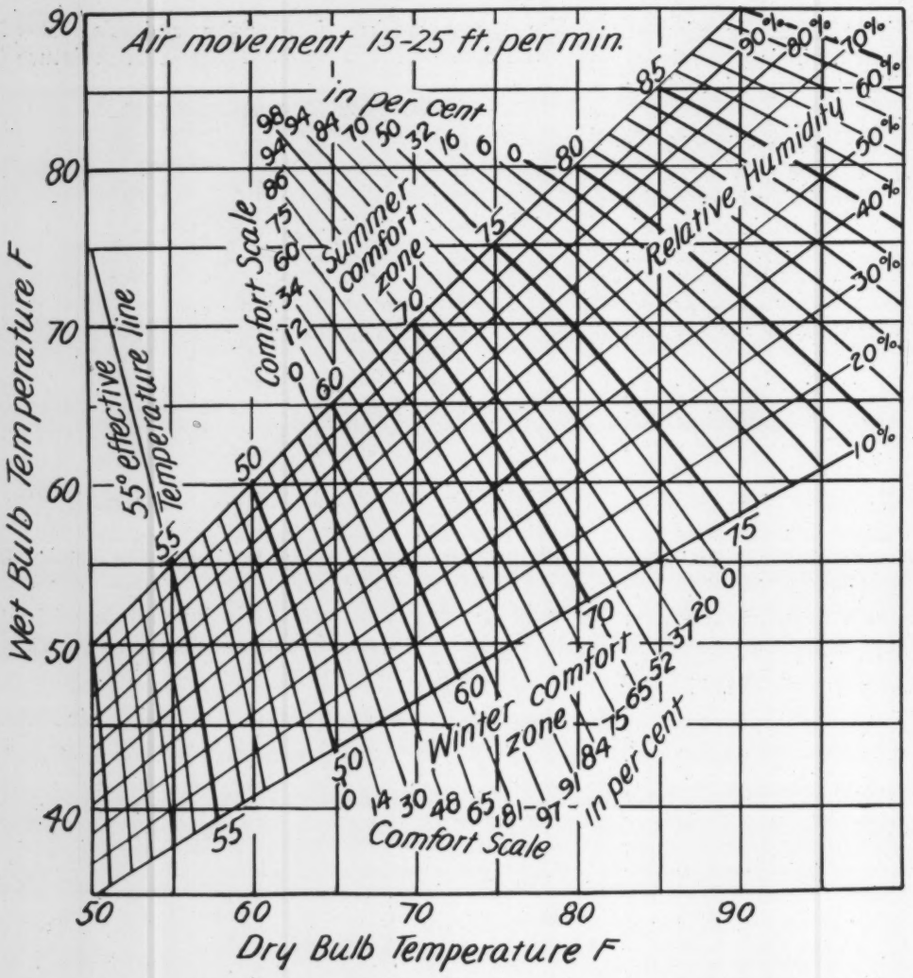


FIG. 4—EFFECTIVE TEMPERATURE CHART WITH COMFORT ZONES SUPERIMPOSED

Optimum Indoor Air Conditions

No single comfort standard can be laid down which would meet every purpose. There is an inherent individual variation in the sensation of warmth or comfort felt by persons when exposed to an identical atmospheric condition. The state of health, age, sex, clothing, activity, and the degree of acquired adaptation seem to be the important factors which affect the comfort standards.

The optimum temperature for the fetus is the temperature of the mother's uterus. The optimum for prematurely-born infants varies from 100 F to 75 F, depending upon the stage of development. The optimum relative humidity for these infants is placed at 65 per cent (*2*).

No data are available concerning the optimum air conditions for full term infants and young children up to grade school age. The satisfactory conditions for these age groups are usually assumed to vary from 75 F to 68 F in temperature with natural indoor humidities.

For school children, the studies of the New York State Commission on Ventilation (*24*) place the optimal air conditions at 66 F to 68 F, with a moderate humidity and a moderate but not excessive amount of air movement. Allowing for the influence of room occupancy upon the optimum temperature (*33*) the data of the New York State Commission on Ventilation are fairly in accord with the winter comfort zone determined by the research laboratory of the *American Society of Heating and Ventilating Engineers* for men and women over eighteen years of age, under sedentary conditions (*34*).

Fig. 4 shows this zone, and its seasonal variation from winter to summer. According to the consensus of the experimental subjects, an effective temperature of 66 F is the most popular in winter time, whereas in summer one of 71 F is the most desirable. The relative humidity in these experiments was varied from about 30 per cent to 75 per cent, but the optimum range has not been determined. For general air conditioning, a range of 40 per cent to 70 per cent is assumed, the former representing a maximum winter condition and the latter a maximum summer condition. Relative humidities higher than 40 per cent are often impracticable in cold weather on account of condensation of moisture and frosting on the window glass.

The optimal air conditions for health are not so well known as those for comfort. To solve the question, it would probably be desirable to make observations in institutions of confinement where the living conditions can be controlled over a considerable length of time.

The Control of Indoor Air Conditions

Natural Methods of Ventilation

Residences and office rooms, where there is no overcrowding, are usually ventilated by opening the windows top and bottom. This is the simplest of methods. Transoms and sash ventilators are often provided to assist

in the circulation of air, and to reduce the drafts due to the cold air entering through the partly open windows. Such places are usually heated by direct radiation or by means of a warm air furnace. This latter method may in itself provide for ventilation when part of the air circulated is taken from out-of-doors.

For the more crowded offices, for school rooms and hospital wards, window ventilation is uncertain and makes proper heating difficult. Such rooms are frequently ventilated by the so-called "gravity exhaust" method, in which the outdoor air enters over slanted boards or deflectors on the window sills, and the vitiated air is removed through exhaust ducts or flues, at or near the ceiling on the wall opposite the windows. These flues lead to the roof. The circulation of air is induced largely by the difference in density between the cold air out-of-doors and the warm air indoors. Ventilation may be accelerated by placing a roof ventilator on the top of the exhaust duct, which acts as an aspirator under the action of the wind.

In places ventilated by natural methods the problem of humidity control is a rather difficult one, particularly in cold weather. Not infrequently the relative humidity is lowered to 20 per cent or less as a direct result of artificial heating. A large quantity of water must be evaporated to raise the relative humidity to 50 per cent.

In warm summer weather, natural methods of ventilation afford little or no control of the temperature and humidity, except when they are supplemented with special cooling apparatus. Such apparatus is now rapidly coming into common use, though at present it is largely confined to theaters and to certain industrial plants, on account of its cost. In the home, office, and hospital rooms, the effects of summer heat may be alleviated to some extent by the use of portable desk fans.

The chief disadvantage of natural ventilation methods is the lack of control. They depend largely on weather and upon the velocity and direction of wind. Rooms on the windward side of the building may, sometimes, be difficult to ventilate on account of drafts, while rooms on the leeward side may not receive an adequate supply of air from out-of-doors. The partial vacuum produced on the leeward side under the action of wind may even reverse the flow of air from the rooms and corridors to the out-of-doors, through the open windows and gravity exhaust ducts.

Natural ventilation methods are simple and low in cost, and they are psychologically pleasant to the occupants.

Mechanical Systems of Ventilation and Air Conditioning

In densely occupied spaces, such as theaters, auditoriums and crowded school rooms, or where there is a specific source of vitiation calling for a constant supply of pure air, resort must be made to mechanical methods. In these systems the air circulation is maintained by means of fans which either force the air into the space to be ventilated through a system of metal ducts, or remove the vitiated air by suction. In many instances a combination of these two methods is necessary.

The heating is often accomplished by a combination of direct and indirect methods, the so-called "split system," in which the ventilating current is tempered to about room temperature or slightly below. In some instances no direct radiation is provided and the ventilating air furnishes all the heat necessary.

In the past, the practice has been to supply each occupant with 30 cu. ft., or more, of air per minute, and this was made the basis of ventilation laws in many states. The present tendency is to furnish a smaller amount of properly conditioned air, the volume depending upon the actual requirements of the particular problem.

Mechanical systems of ventilation are especially adaptable to complete air conditioning. This involves filtering, washing, heating, humidifying, cooling and dehumidifying the air circulated through the system. All of these processes are often accomplished by means of a central air conditioning apparatus from which metal ducts branch off to the various rooms.

In dusty and smoky localities, the air is filtered by placing at the intake opening some filtration media, like cloth, or an oil-coated metal screen, to which the coarse dust particles adhere.

Where humidification or cooling and dehumidification is desired, in one type of system the air is passed through a rectangular chamber where it comes in contact with a finely atomized spray of water emerging under pressure from spray nozzles. This procedure washes off some of the dust in the air and removes soluble impurities. At the same time the air absorbs or gives up moisture, according to the temperature of the spray water. In winter, when humidification is desired, the spray water is heated. In warm and humid weather, the air is cooled and dehumidified by contact with the cold water spray. The water is cooled in a separate chamber by trickling over cold pipes through which brine is circulated under pressure. Finally, on leaving the spray chamber, the air is forced through heaters, which in winter warm it to the desired temperature. A system of metal ducts, running through, or along, the walls carries the conditioned air to the different parts of the building. The various processes are controlled automatically by means of thermostats and humidostats, which are set to maintain any desired air condition in the rooms.

Systems of mechanical ventilation and air conditioning are usually equipped for reconditioning and recirculating part of the air in the interest of economy. The popular belief regarding the alleged virtues of ozone in recirculated air seems unfounded, to the writer. Concentrations permissible in ventilation work were found to exert no effect on air-borne disease organisms (*35*). It is also a question whether ozone at such concentration actually destroys odors by oxidation, or whether it merely masks them by olfactory compensation.

The chief advantage of mechanical ventilation systems is the flexibility in control, regardless of weather conditions, and their adaptability to complete air conditioning. They are, of course, more costly and more complicated than the natural systems, and they require periodic supervision by experts. No matter how perfect they may be in design and construction, their success depends largely upon the manner in which they are operated.

Schoolroom Ventilation

Natural and Mechanical Methods

The problem of school room ventilation in relation to the health of the school children has been the subject of many studies and controversies, and some important points are still considered debatable.

The first studies of the New York State Commission on Ventilation (*24*) indicated that systems of mechanical ventilation lead to higher rates of respiratory illness among the pupils than do the natural methods, with window supply and gravity exhaust. This was attributed mainly to the higher room temperatures necessary on account of the higher air change in the rooms supplied by fans. Subsequent studies (*36, 37, 38*) repeated by the commission and by others under somewhat more comparable conditions yielded similar results, as far as incidence of respiratory illness is concerned.

The latest studies of the commission (*39, 40, 41*), which are much more thorough, do not entirely confirm the earlier findings, and they seem to contradict some of the points at issue. Neither the temperature, nor the rate of air change, nor the air velocity in the classrooms was found to affect the incidence of respiratory or other forms of illness among pupils. The apparent superiority of the "window gravity" methods in the earlier studies is attributed in the last reports largely to uncompensated variables, such as race, age, sex, social and economic status, the distance the pupils had to travel to reach school, and difficulty in the diagnosis of respiratory illness.

These last studies (*39, 40, 41*) warrant the conclusion that the incidence of respiratory illness is not a satisfactory criterion for judging the effects of air conditions on the health of school children.

Special tests on the ability of several school nurses to diagnose respiratory illness in a given group of children disclosed that the best agreement between any two nurses was in the ratio of 1 to 3 and the worst agreement in the ratio of 1 to 9. Presumably, this ratio was even smaller in the commission's first study, in which the diagnosis was made by teachers and parents.

In the light of our present knowledge of the requirements for school room ventilation, it seems fair to say that natural methods are to be preferred *wherever they can be safely and economically applied.*

Special Methods of Ventilating Schoolrooms

According to the experience of the New York State Commission on Ventilation, in school rooms where the vitiation is entirely of human origin, the chemical composition of the air, the dust, and the bacteria content may be dismissed from consideration, so that the problem consists in maintaining a temperature of 66 F to 68 F, a moderate relative humidity and an air change sufficient to avoid an excessive concentration of effluvia.

In many instances, these requirements can be fulfilled adequately by the modified gravity systems of ventilation. The principal conditions necessary for the success of these systems are outlined as follows (*24*):

a. Radiators of ample capacity must be provided beneath the windows and they must extend for the full width of the windows to be opened. These radiators should be controlled automatically by intermediate acting thermostats, or should be equipped with fractional hand valves, or both.

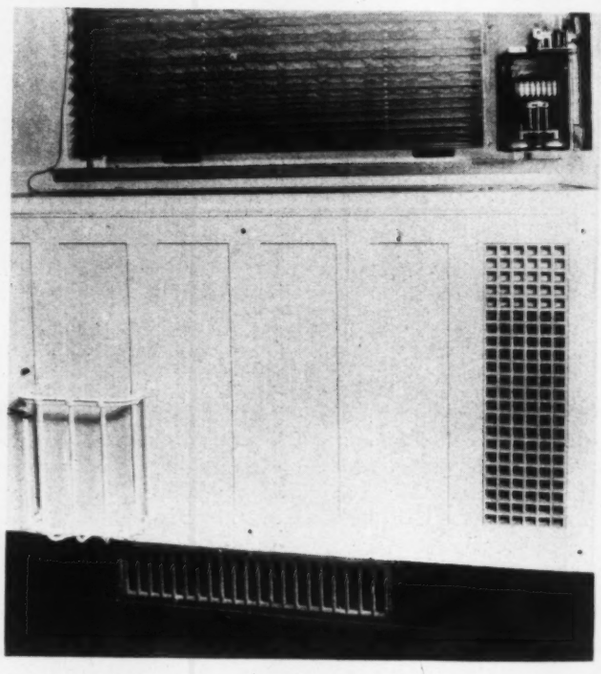
b. Deflecting boards, preferably curved vane deflectors, should be placed at the bottom of the windows to direct the entering air upward. The windows should open from the bottom, not from the top, and they should be provided with double window shades adjustable from top and bottom, to prevent shaking by the air currents.

c. Exhaust ducts having an area of not less than 8 sq. ft. for an ordinary school room should be provided on the wall opposite the windows. These ducts must be properly dampered and furnished with an aspirating cowl on the opening at the roof, or with a heating coil inside the duct, or both.

d. The schoolrooms must not be overcrowded. They should be large enough to provide about 250 cu. ft. of air space for each child of second grade (39 children in an ordinary school room) and 310 cu. ft. per pupil of the sixth grade (31 children in an ordinary school room).

The commission does not favor artificial humidification in school rooms, because their data do not disclose any striking improvement in the health or efficiency of the pupils in humidified class rooms. It should be noted, however, that the humidity range employed was small and that the experiments were short in duration.

These recommendations are made for the average school room, so situated that the system of modified window ventilation can be safely and economically applied. There will be some school rooms which, on account of overcrowding (more than 50 students in a room), inadequate construction, unfavorable exposure to cold climate, wind, noise, or dust, would require some type of mechanical equipment. The chief object, in any particular case, should be to secure the desired conditions, by natural methods if possible, or by mechanical methods, if necessary. School room ventilation laws in states and cities often do not insure satisfactory ventilation because, as a general rule, they arbitrarily fix methods rather than the results to be secured. The inade-



GRILLES FOR SUPPLYING FILTERED AND CONDITIONED AIR TO AN EXAMINATION ROOM IN A CLINIC

quacy of these laws is evident from their lack of uniformity in the various states and cities.

The heating and ventilation of rural schools constitutes a distinct problem. The majority of these schools consist of one or two rooms heated by means of a stove, and inadequately constructed with respect to sanitation and ventilation. Studies of air conditions in relation to the health of the pupils in one-or two-room schools of Cattaraugus county (*42*) reveal that the average total absenteeism and the absenteeism due to respiratory diseases was twice as high as that found in the Syracuse schools studied by the New York State Commission on Ventilation. The stove heated schools showed a very uneven distribution of heat both laterally and vertically, as represented by differences in temperature as great as 30 F or 40 F in different parts of the room.

A simple method for securing a certain amount of ventilation in rural schoolrooms is to remove the upper glass pane of some of the windows and cover the opening with very fine mesh copper screen or cloth. In this way, objectionable drafts are avoided and some of the dust in the entering air is caught by the screen.

Outdoor versus Indoor Life

We are living now in an age when the value of outdoor life is realized more than ever before. It is believed that certain reflexes of the autonomic nervous system are associated with health and they are controlled by climatic factors. Jakoneuko (*43*) thinks that wind and ultra violet light are probably the chief factors. Whatever factors are involved, there is no question whatever that, under favorable weather conditions, living out-of-doors is more healthful than living indoors. This is attested by gains in weight and marked improvements in the general health of children living under tents or in summer camps. Air conditioning, even at its best, cannot entirely equal the wholesome natural atmosphere of an ideal day. It is corrective under adverse weather conditions, or in crowded places, factories and the like, where it constitutes the only means by which an adequate supply of pure air can be procured.

We must admit, however, that in guarding against cold we are deliberately creating indoors an overheated and dry atmosphere which affects susceptibility to respiratory diseases and lowers the general vasomotor tone. A room temperature between 60 F and 70 F, on the other hand, with ample ventilation but without harmful drafts, is a vasomotor stimulant and it lessens the contrasts of transition from the indoor to the outdoor atmosphere.

Some physicians still believe in the potency of outdoor air as a cure-all for human ills, regardless of weather conditions. This belief has led to the establishment of certain schools in which in winter subnormal children are heavily clothed and exposed to unmodified weather, on the assumption that the breathing of cold air is a tonic to general health. Very recent work by Vernon and Bedford (*44*) shows that in cold weather the efficiency of children attending open-air schools in England was only about half that of children in ordinary heated schools. The absenteeism was greatly influenced by temperature, as much as 50 per cent during a very cold period of time, owing largely to the restraining influence of parents.

Presumably, other factors such as proper nutrition, opportunity for extra rest, and individual medical care are in themselves sufficient to counteract the effects of unfavorable exposure. In the light of our present knowledge of the physiology of ventilation, open air schools of this extreme variety are dangerous in winter, but they are of great value when the weather is favorable, particularly if the schools are located in clean and quiet districts.

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Heat Accumulator Stores Hot and Cold Water

The Hamburg (Germany) Electricity Works supplies current to the city of Hamburg and also hot water from its central heating plant for heating offices and public buildings. It is equipped with a large hot water tank of 2,650-ton capacity which serves as a heat accumulator. Waste heat from the turbines is utilized for the production of hot water, this being the main function, and the power generated is virtually a by-product.

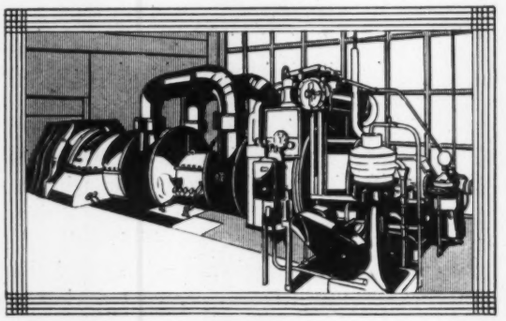
The demand for heat varies not only with the season but also with the time of day—being large in the morning, and falling off quickly as the buildings are heated up and the outside temperature rises—making the heating load and the electrical production irregular, with an adverse influence on the heating costs. By the installation of the heat storage tank it is possible in winter to keep the boilers as well as the turbines under an equal load nearly all day, and to use both sections of the plant to better advantage. With peak loads at night, back pressure is taken off the turbines, and the plant is used primarily for generation of electricity.

The tank, which is 30 ft. in diameter and 115 ft. high, is sufficiently large to store the heat not only from the existing plant but also from an extension, which will comprise a 1,400-lb. boiler plant and a 20,000 kw. back pressure turbine.

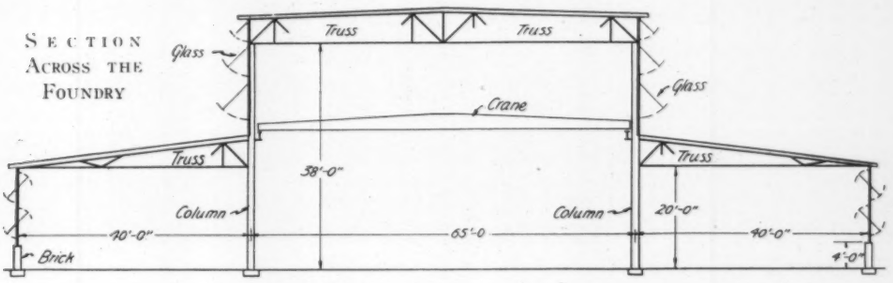
The tank is placed in the center of the heated district, about 2,700 ft. from the generating plant. It can store enough heat to supply the system for five hours; the water in it can be heated to 130 F.

As the tank serves to store not only the hot water before it goes to the buildings, but also the returning cold water before it goes back to the power station, there is cold water in the lower part and hot in the upper, the proportions varying widely. In order to regulate the quantities, inlets for hot water are provided at three different levels. The outlet for hot water is at the top and the inlet and outlet for cold water at the bottom of the tank. The cold and hot water are separated by an insulated partition, which is raised or lowered in accordance with their relation to each other.

The tank is said to be the largest heat storer in the world, and was built up entirely by electric welding. It is set upon a reinforced concrete foundation 6 ft. deep. The bottom plates are 0.4-in. thick, the lower side plates have a thickness of 0.8-in. and the uppermost, of 0.25-in. There are twenty circular 6-ft. rings. The welding was effected by means of V-seams from the inside; the outside was strengthened by welding laps across the seams.—*A. C. B.*



In this article, the author shows the advisability of a careful engineering analysis when it is desired to heat buildings for the least money—as it usually is. In the typical plant assumed it was found—when the analysis was completed—that unit heaters would save over $1,700 per year in the cost of fuel and labor for heat. Obviously, in another building this might not be true, or the situation might be reversed. The point Mr. Lewis makes is the necessity of analyzing the heating of a building in order to prevent waste, and his article shows how it was done for one plant.



$1,739 Reduction in Annual Heating Cost Indicated by Consulting Engineer's Study

Need for a Thorough Analysis Demonstrated in This Typical Plant

By Samuel R. Lewis*

"Before" One of the manufacturing establishments of a large corporation—which makes castings, machines them, and which then combines them with structural steel into a well known and universally needed product—is scattered over a large area, and includes buildings of many different types, various ages, and in various conditions.

Electric energy for the plant is purchased from a public service company. There is comparatively little process heat required. The three large water tube boilers which furnish steam for heating by direct radiation and blast radiation are hand-fired. The connected load using steam directly is 4,000,000 Btu per hr. The foundry uses forced circulation hot water, heated by steam at the boiler house, and its demand is about 6,050,000 Btu per hr. in addition to the foregoing 4,000,000 Btu.

About 1,600 tons of bituminous coal are burned per year, at a cost for fuel and labor and boiler house maintenance (neglecting fixed charges) of $11,000.00 annually. Thus for the connected hourly demand the cost of heat per year is about $1.10 per 1,000 Btu. (The cost of heat per equivalent square foot of direct steam radiation is 26 cents per year, and each equivalent square foot of direct steam radiation requires about 76 lb. of coal per year.)

No recording instruments are utilized, and no records are available for separating the costs of heating any of the buildings from that of all of the buildings.

Live steam is used in copper-tube transfer-heaters for heating the water for the foundry, which is pumped through insulated and weatherproofed pipes run overhead on posts about eight hundred feet across a meadow which separates the foundry from the machine shops, offices, garages, storehouses, etc.

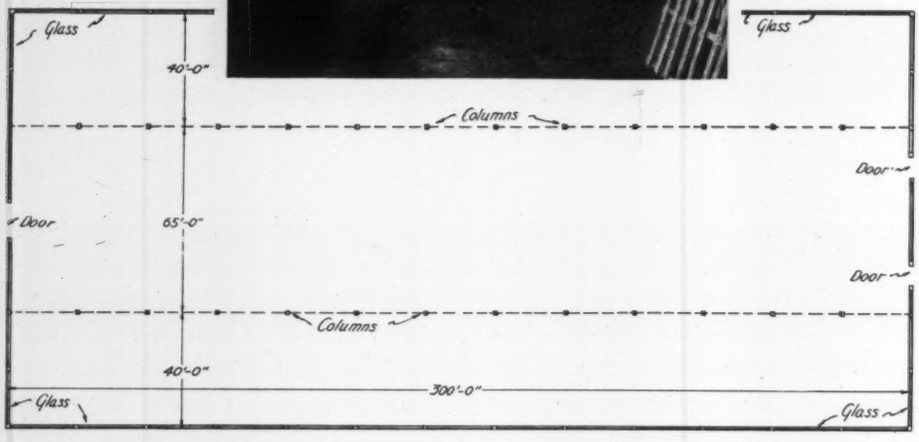
Foundry Construction

The foundry is three hundred feet long, about forty-five feet high, and one hundred and forty-five feet wide. It has glass sides above a 13-in. brick base about four feet high, glass ends, glass skylights with sides arranged

* Consulting engineer, Chicago, Ill.

RIGHT—A TYPICAL FOUNDRY INTERIOR, SHOWING THE HIGH ROOF AND THE LARGE GLASS AREAS

BELOW — PLAN OF THE FOUNDRY. THE AUXILIARY SAND-STORAGE AND PREPARATION BUILDINGS ARE NOT SHOWN



to be opened, and a composition roof laid on thin tile-shaped interlocking slabs of reinforced concrete. It has had none too good maintenance care.

The thin brick walls along the outside of this foundry are lined with great hot water pipe coils many tiers high. Every column in the building has an enormous vertical hot water pipe coil clinging to it. The spaces between the columns overhead, longitudinally, where the cranes will not strike them, all are lined with hot water pipe coils.

Even in mild weather, so cold was the foundry, despite all efforts to heat it with the direct hot water radiation, that big coke-burning salamanders were required throughout the molding area. The hands of the workmen would get cold and stiff and with the heat supply so far overhead they found the direct heat from the glowing coals exceedingly grateful.

No Heat Regulation

There are a few valves here and there, mostly inaccessible except by balloon, for controlling the water flow in the coils, but they have been forgotten for years, or their wheels have been knocked off, so that no radiation ever is shut off or turned on. Such regulation of temperature as ever is attempted is done by opening the windows and letting the surplus heat escape.

The engineer over in the boiler house, if he happens to think of it, can step outside and look at a spot on the wall where a thermometer used to be, and can then go back inside and climb a precarious ladder up among the dim fastnesses of the boiler house roof where he can throttle or open a valve on the steam connection to the hot water transfer-heater—but he hardly ever does.

As no record of the interior temperatures on a zero day are available, they must be assumed. Suppose it is said that without the use of salamanders, with zero outside, neglecting sun effect, the plant as installed could maintain 40 F at the breathing line.

Temperature Gradient:

Well-authenticated data from tests and experience gives a temperature rise in buildings of this nature of two degrees per foot of height above the breathing line. That is, if there is 40 F at the breathing line and if the average height of the center part of the building is 41 feet, the equation becomes:

$$(41 - 5) \times 2 \text{ plus } 40 = 112 \text{ F under roof.}$$

And for the side buildings:

$$(22 - 5) \times 2 \text{ plus } 40 = 74 \text{ F under roof.}$$

The following temperatures, therefore, will be assumed: Floor, 30 F; breathing line (5′), 40 F; ceiling (center building), 112 F; side walls (center building), 100 F; ceiling of side buildings, 74 F; side walls of side buildings, 70 F.

As a matter of fact it is known that the core sand and the water pipes freeze along the floor, and that much of the outside wall surface, lined with hot water pipes, is heated to over 200 F. The exact interior condition, while of historical interest, is of no great moment, provided that some fair assumption for comparative purposes can be taken.

Heat Transfer Coefficients:

Let us then compute the heat loss on the basis of the assumed temperatures for direct radiator heating:

Each square foot of single glass loses 1.13 Btu per hr. per degree difference in temperature.

Each square foot of 13-in. unplastered wall loses 0.295 Btu per hr. per degree difference.

Each square foot of cement tile roof of the type in this building loses 0.68 Btu per hr. per degree difference, and each square foot of floor loses about 0.56 Btu per hr. per degree difference.

Stack Effect:

A heated building is like a hot air balloon. The lighter warm air at the top seeks diligently to escape, and leakage is outward at all crevices above the neutral zone of the building. Below the neutral zone leakage of the cold outside air is inward. The neutral zone varies with temperature differences but is observable in every heated building. It is a different and separate phenomenon than that due to wind.

Infiltration:

In this analysis it is considered that the wind will affect different types of heating systems in similar ways, and therefore the wind is ignored, since these figures are comparative.

Infiltration due to the great outward air pressure at the top of the room, however, is a function of the area through which leakage can occur rather than of the contents of the room. For ordinary rooms in multi-story buildings which are exposed only on their edges, an allowance for leakage of 30 per cent of the heat loss by convection and radiation has been found about correct.

Tabulation of Heat Losses Where Heating Is Done By Direct Radiation:

TABLE 1

	Btu
Upper level glass in center building	
8700 sq. ft. x 1.13 x 100 F	983,100
Lower level glass in center building and glass in side buildings	
14260 sq. ft. x 1.13 x 70 F	1,127,966
High level walls in center building	
3727 sq. ft. x 0.295 x 100 F	109,946
Low level walls in center building	
6647 sq. ft. x 0.295 x 70 F	137,260
Total side wall and glass losses	2,358,272
30% of above for leakage	707,481
Roof center building	
20100 sq. ft. x 0.68 x 112 F	1,530,816
Roof side buildings	
24600 sq. ft. x 0.68 x 70 F	1,170,960
Floors of center and side buildings	
44100 sq. ft. x 0.56 x 10 F	246,960
Original hourly heat loss with direct radiation	6,014,489

Not Enough Radiation

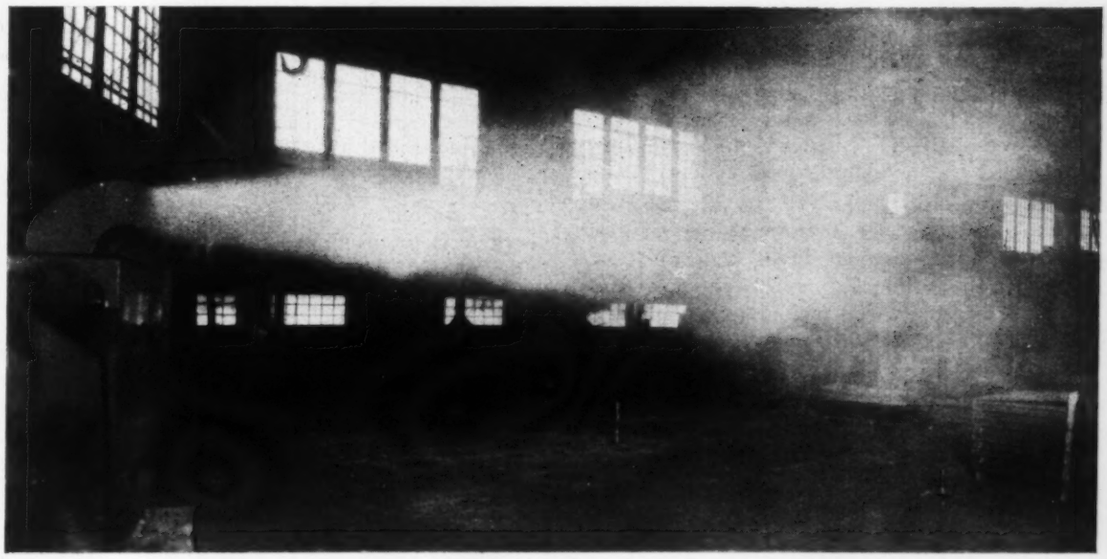
There are installed in the building, including the surface of mains, 20,000 sq. ft. of pipe surface. This means that each square foot of this surface is expected to transmit about 300 Btu per hr., a reasonably arduous task even for a well-arranged pipe surface.

However, these pipes are *not* well arranged, as a great deal of the surface is so placed that the only convection currents of air likely to rub over it already have been warmed by contact with lower-down surfaces. As the temperature is often far below zero out-of-doors, no wonder it is necessary to use salamanders, as there just isn't room to squeeze in any more radiation.

Estimated Heat Loss With Unit Heaters

Although exact fuel consumption data are lacking it is interesting to construct comparative figures to visualize what would be the effect of a different method of heating.

A SMOKE TEST SHOWING A HIGH VELOCITY FLOOR TYPE UNIT HEATER IN ACTION. THE WARM AIR IS DIVERTED MECHANICALLY TOWARD THE FLOOR BELOW THE ARTIFICIALLY-CREATED INVISIBLE CEILING OF COOLER AIR AGAINST THE ROOF. THE WARMER AIR OF THE LOWER ZONE IS PULLED BACK TO THE HEATER



"After" Suppose hot water heated electric fan-driven recirculating unit heating machines were installed to do the work. They create a warm zone in the lower part of the room, neglecting the unnecessary heating of the lofty spaces up among the trusses. The crane operators have electric heaters in their cabs anyway.

The temperature rise per foot of the height above the breathing line when unit heaters are used is about one-half of one degree; also with the artificial temperature-pressure in the lower zone due to the fans, and with the cooler air up above, the leakage is reduced materially: but no present credit for this additional saving is taken in the tabulation.

The heat loss calculation is changed because of the reduced high-up interior temperatures, which become: Floor, 40 F; breathing line, 50 F; ceiling of center building $[(41-5) \times 0.5 + 50]$, 68 F; side walls of center building, 60 F; ceiling of side buildings $[(22-5) \times 0.5 + 50]$, 59 F; side walls of side buildings, 55 F.

Tabulation of Heat Losses When Heating Is Done By Unit Heaters:

TABLE 2

	Btu
Upper level glass	
8700 sq. ft. x 1.13 x 60 F	589,860
Lower level glass	
14,260 sq. ft. x 1.13 x 55 F	886,259
High level walls	
3,727 sq. ft. x 0.295 x 60 F	65,967
Low level walls	
6,647 sq. ft. x 0.295 x 55 F	107,848
Total side wall and glass losses	1,749,934
30% of above for leakage	524,979
	2,274,913
Roof center building	
20,100 sq. ft. x 0.68 x 68 F	924,424
Roof side buildings	
24,600 sq. ft. x 0.68 x 59 F	986,952
Floors of center and side buildings	
44,100 sq. ft. x 0.56 x 10 F	246,960
Revised hourly heat loss with unit heaters	4,433,249

Heat Saved

The saving made by heating the building with mechanically driven unit heating machines is, conservatively, the difference between 6,014,489 Btu and 4,433,249 Btu, or 1,581,240 Btu per hr., or about 26 per cent.

At a unit cost of $1.10 per 1,000 Btu, this means a reduction of $1,739.00 per year in the cost of fuel and labor for heat, neglecting capital investment and not counting the saving due to elimination of the salamanders, and the fuel and labor which they require.

The calculations also are based on a ten-degree higher temperature at the floor and at the breathing line than with the old system.

Initial Cost of New System

The cost of such a change in the heating of this building is approximately $6,000.00. The first year would show a statement like this:

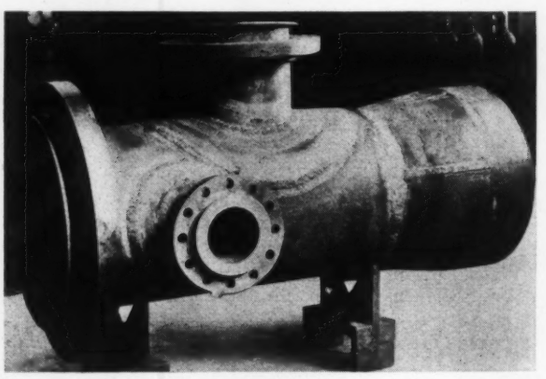
TABLE 3

Investment	$6,000.00	
Interest on $6,000.00 @ 5%	300.00	
Saving in fuel		$1,739.00
Balance remaining in investment		4,621.00
END OF SECOND YEAR:		
Investment	$4,621.00	
Interest on $4,621.00 @ 5%	231.00	
Saving in fuel		1,739.00
Balance remaining in investment		3,113.00
END OF THIRD YEAR:		
Investment	$3,113.00	
Interest on $3,113.00 @ 5%	155.00	
Saving in fuel		1,739.00
Balance remaining in investment		1,529.00
END OF FOURTH YEAR:		
Investment	$1,529.00	
Interest on $1,529.00 @ 5%	76.00	
Saving in fuel		1,739.00
Investment all cleared with margin of	134.00	

Fabrication of a Pipe Special

Special and odd shaped fittings are fabricated by welding in one large plant.

One of the specials, shown below, consisted of a length of 22-in. pipe with a Van Stone type flange at one end and a 26x22 in. reducer at the other. This reducer was fabricated from a short length of 26-in. pipe.



WELDED PIPE SPECIAL FOR A NATURAL GAS LINE

The number of cuts required in making the reducer was first calculated from the formula:

$$N = 4/3\ (D_1\text{-}D_2)$$

where N is the number of cuts, and D_1 and D_2 are the diameters of the large and small pipes, respectively. This formula gave five as the number of cuts to be made. A templet was then laid out and the cuts made according to the templet, using a cutting torch. The cut edges were beveled, and scale from the cutting operation removed. Using a welding flame, the segments were then heated, swaged into contact, and welded together. The smaller end of the reducer was welded to the 22-in. section of the special with a single vee butt weld.

Two Van Stone nozzles were also welded to the 22-in. section, reinforced with saddle plates welded on.

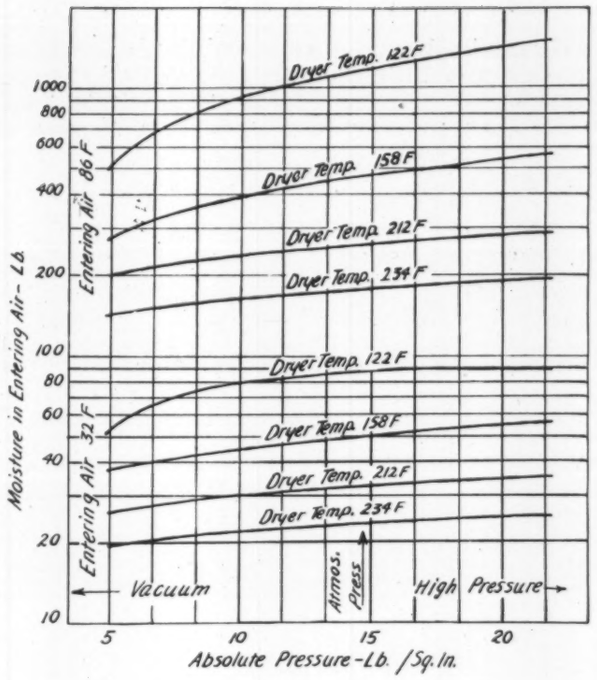


FIG. 1—EFFECT OF PRESSURE IN MOISTURE REMOVAL. CONDITIONS—220 LB. MOISTURE REMOVED; AIR SATURATED AT ENTRANCE AND EXIT

By Malcolm Tomlinson*

Charts Show Fundamentals of the Drying Process

The charts presented with this article make it possible to see at a glance the effect of a change in one of the factors which influence the drying process. Control instruments are also discussed

DRYING is an outgrowth of the demand of trade for uniformity and quality in merchandise. It prevents deterioration of goods in transit and in storage and presents merchandise to the buying public in its most pleasing aspect.

The Factors Involved

To secure these requisites the first step is to determine the physical and chemical variations permissible for the product. This involves characteristics such as strength, size, weight, shape, texture and color; they are affected by the heat applied, the vapor pressure of the air and product and the rate at which air moves. Even though the circulation of air is by gravity heat and air motion are fundamental necessities. The drying process may thus be said to depend on controls which include air temperatures, atmospheric pressures, air motion and, possibly, relative humidity. Without these factors it would be helplessly handicapped.

But drying control involves something more than a device which supplies two or three of these factors. A watchman is needed in the form of instruments, automatic regulation, operating records of a permanent nature, fundamental information on the product and on drying and, most of all, intelligent supervision. Any discussion of drying must include these broader aspects of control.

Temperature and humidity limitations of the product depend on varied considerations. Rubber products must have enough heat for vulcanization, hay requires a golden color and a definite aroma, paper must be protected against loss of color and destruction of its hygroscopic structure. Air pressure and air motion, on the

* Consulting engineer, West Chester, Pa.

other hand, are mainly vehicles by which the moisture removal rates may be changed. One important exception to this last statement should be noted; low pressures (below atmospheric) make higher temperatures possible.

Effect of the Factors on the Drying Rate

The effect of the four factors on the drying rate is of the utmost importance. An example of the effect of pressure and temperature can be seen in Fig. 1, while further effects may be found in Figs. 5 to 8 inclusive. Briefly, it can be stated that an increase in the drying rate can be secured by increasing the temperature or the air motion or by decreasing the pressure and the relative humidity. When all four factors are employed at their economic limit, maximum drying will be obtained. Beyond this limit the cost of production increases abnormally. The determination of the economic factor limits should rest with the dryer manufacturer.

Relative Humidity Recorders

Most forms of indicating instruments are so well known that they need no particular mention here. Improvement, in recent years, has been made in types used for the measurement of humidity. One of these is a wet bulb thermometer graduated to read directly in terms of relative humidity. This instrument is based on a single value of the dry bulb temperature but corrections for the several dry bulb temperatures above and below the optimum are noted on its frame.

Recording instruments remove the necessity for a daily log. They can be used for direct automatic control purposes. Here again considerable progress has been made in the humidity field. One such instrument consists of two Wheatstone bridges mounted in a recorder, a separate wetting device and two resistance thermometers; diagrams are shown in Figs. 2 and 3. The bridges are individually balanced and connected so that the recording pen is given a motion identical with the ratio $\frac{W+a}{D+B}$ in which the letters W, D, B and a have

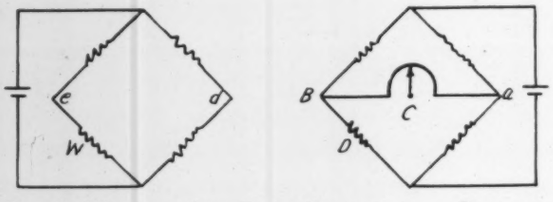


Fig. 2—Wet and Dry Bulb Circuits in a Relative Humidity Recorder

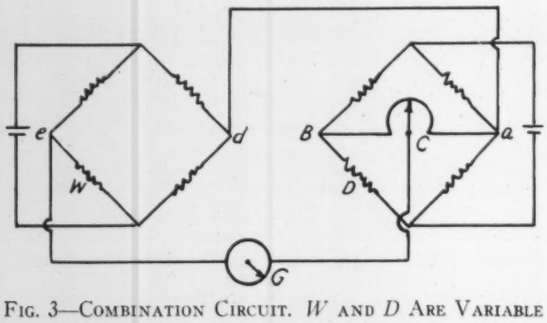


Fig. 3—Combination Circuit. W and D Are Variable Resistances; G Is a Galvanometer; C Is a Slide Wire

the significance indicated by Fig. 4. This ratio or slope is the relation between the wet and dry bulb temperatures and the relative humidity. Though the instrument described can not be used for relative humidities below 20 per cent it is possible to obtain recording instruments

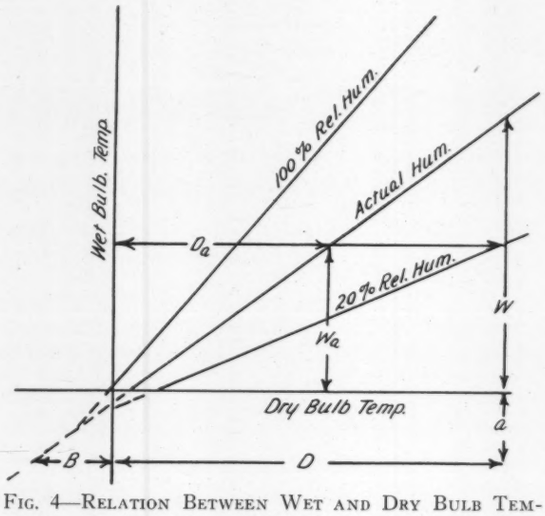


Fig. 4—Relation Between Wet and Dry Bulb Temperatures and Relative Humidity

which will measure either the relative humidity or the dewpoint down to a hundredth of a per cent.

Modern instruments for temperature and humidity measurement are of rugged construction even when of the precision grade. Interchangeability without additional calibration, sensitivity through accurate balance, compensation so that length of leads does not affect the reading and designs which eliminate error are features which are readily obtainable.

Most humidity instruments use the wet and dry bulb principle. While other means besides cotton and silk wicks are used to keep the wet bulb coated with a film of water no method will insure a clean wick unless the proper attention is given the instrument. Since dust and dirt, from the air, and salt crystals, from the water, clog the wick and interfere with the flow of water and since accurate results depend on the maintenance of the water film over the wet bulb surface it is evident that a wet bulb thermometer requires correct maintenance.

Valves, Switches, Etc.

Valves, shutters, dampers and switches may be operated automatically by mechanical or electrical methods. One form of mechanical regulation uses an expanding liquid to transmit motion through a device such as a bellows. Electrical methods include sensitive switches or relays as well as direct instrument control. The sensitivity and reliability desired will determine the method employed. The features to be sought are an equal degree of accuracy over the temperature or humidity range likely to be encountered and ability to act within the desired time limit.

Fundamentals of the Drying Process Charted

Fundamental information on the drying process will be found in Figs. 1, 5, 6, 7 and 8, where the effects of pressure, temperature and humidity are shown. These effects, charted, make it possible to see at a glance just

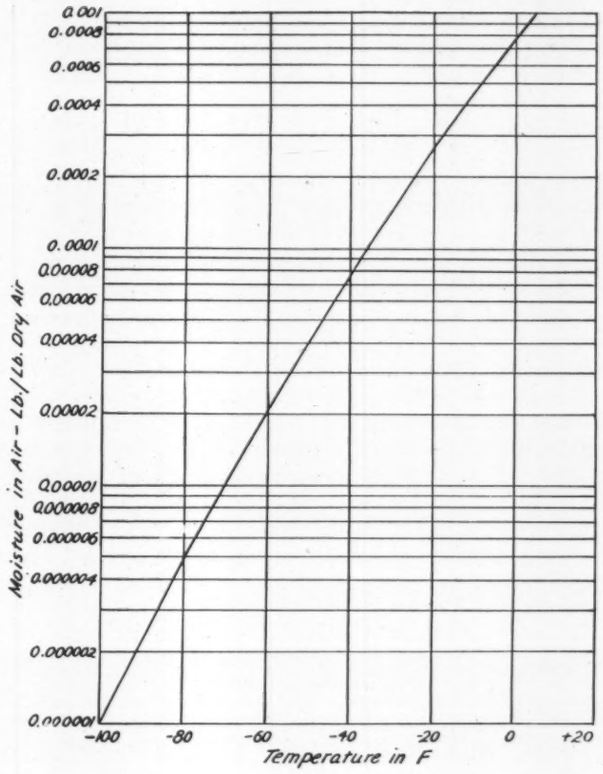


FIG. 5—EFFECT OF TEMPERATURE ON WATER ABSORPTION OF AIR. AIR PRESSURE ATMOSPHERIC. FOR ORDINARY TEMPERATURES, SEE FIG. 7

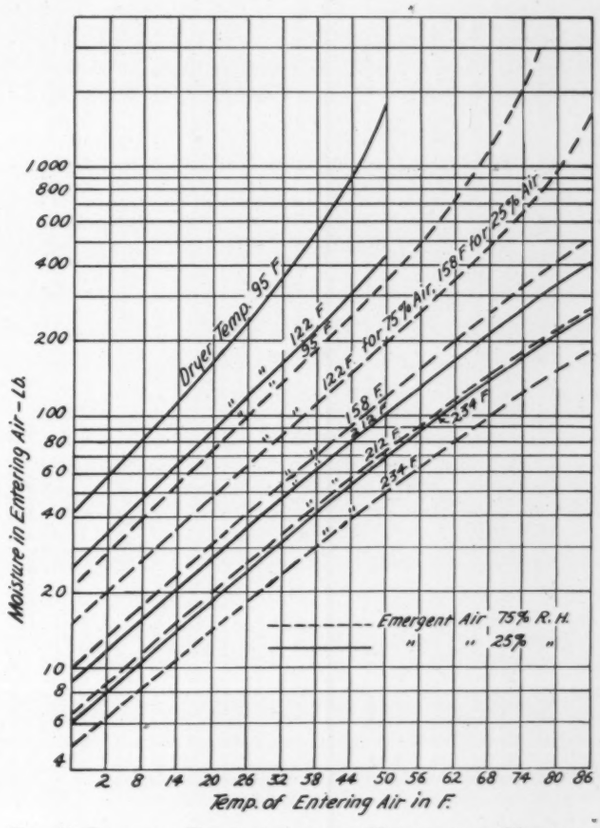


FIG. 6—EFFECT OF TEMPERATURE AND HUMIDITY ON MOISTURE REMOVAL. CONDITIONS—ENTERING AIR SATURATED; PRESSURE OF AIR, ATMOSPHERIC; 220 LB. MOISTURE REMOVED

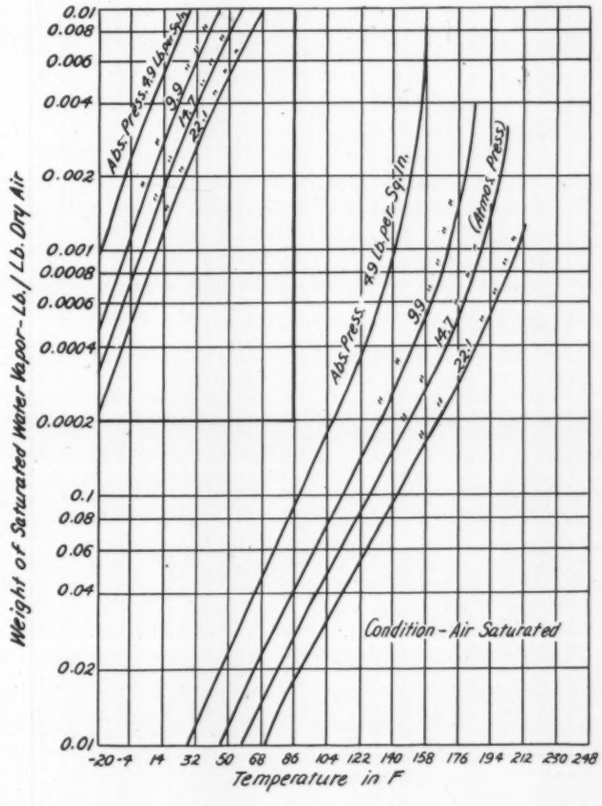


FIG. 7—EFFECT OF TEMPERATURE AND PRESSURE ON WATER ABSORPTION BY AIR

what happens when a given change in some one factor is made. With the semilog charts one can also determine true relationships because, in these charts, values are not distorted when their magnitudes are increased.

Efficiency of Moisture Removal

Since they cover the same calculations Figs. 1 and 8 should be considered together. Furthermore, in Fig. 1, the volume of the entering air is determined by the

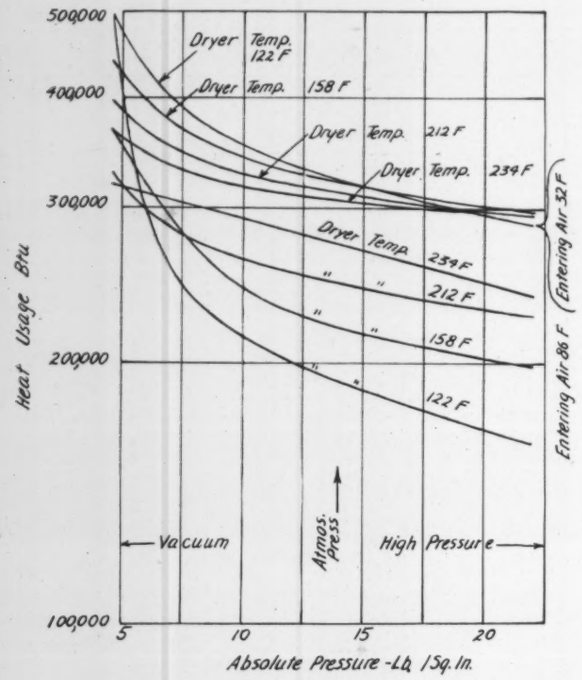


FIG. 8—EFFECT OF PRESSURE ON HEAT USED. CONDITIONS —220 LB. MOISTURE REMOVED; AIR SATURATED AT ENTRANCE AND EXIT

fact that it is saturated and by the weight of the moisture which it carries. In these figures it is evident that efficiency of moisture removal is increased by decreasing the pressure, by increasing the temperature difference and by raising the dryer temperature. It is also evident that a high vacuum, or a very low absolute pressure, decreases the benefits to be secured from a high dryer temperature. When heat consumption is considered the evidence shows that it is increased by lowering the pressure. Here the effect of temperature at the entrance is quite noticeable. The heat required is decreased by increasing the dryer temperature and by increasing the temperature difference.

This discussion of Figs. 1 and 8 is based on calculations for air saturated at both entrance and exit. While Fig. 6 is confined to atmospheric pressure it gives a picture of what happens when the emergent air is not saturated. The two cases illustrated are those of 25 and 75 per cent relative humidity. Here it is seen that efficient drying is had at high dryer temperatures and at high emergent humidities.

Any consideration of vacuum, atmospheric and high pressure drying must, of course, be based on the amount of water which air will absorb. Actually, what is meant is the amount of water that can be taken up by air-water vapor mixtures because air, by itself, can not absorb moisture. From Figs. 5 and 7 it will be observed that such absorption depends largely on temperature and pressure and also that pressures below atmospheric are very efficient. The curve in Fig. 5 will be found quite valuable as it shows the amount of moisture in saturated air at very low temperatures.

The Necessity for Proper Control

With the information presented it will be possible to obtain a picture of the methods by which specific drying problems may be solved. At the same time the data furnished are quite general in character and should be used with this fact in mind. For example, there are no data to show that high temperatures afford an economic solution of any drying problem. Yet the past ten years has seen the design of special boilers for high temperature steam partially for the purpose of drying insulating materials.

The dryer used may be the very best for the purpose. The "set-up" for control may be the finest of its kind in either manual or automatic equipment. The economies obtained in the preliminary runs may be exceptional. Without a day-by-day human supervision and check up of results the time will soon arrive when the quality of the product will start on the downward grade. This is the reason the broader concept of control is so essential to success.

Lack of Radiator Trap Inspection Leads to Steam Waste

By W. T. Jones*

IN MANY plants the importance of keeping the heating system operating efficiently is fully recognized, so that maintenance men are regularly employed for this purpose. Recently the writer had the pleasure of making a tour of inspection of radiator traps with the man in charge of such maintenance in an industrial plant.

"The result of lack of inspection," he said, "is continual waste of steam which causes costs to rise amazingly. When we recently put in our inspection service the vent from the vacuum pump was continually blowing steam, and more cold water had to be used in order to hold a vacuum than was required for make-up. A few days spent in cleaning the traps, and replacing the thermostatic elements in a few traps, worked wonders. We are now running without any jet water at the pump, and as the pump is not steam bound, it stops running when we reach 6 in. of vacuum and remains shut down an appreciable time while the vacuum gradually drops to 3 in., when it automatically starts again."

"Don't you carry a higher vacuum than 6 in.?" I asked. "No," he replied, "nothing is to be gained by a higher vacuum and, of course, the lower the vacuum, the smaller the amount of re-evaporation.

"Isn't this return too hot?" I asked, touching the pipe with my hand. "No," said my friend, "just remember that the radiator and drip traps discharge to this return main at a temperature of about 200 F, and the human hand finds it almost impossible to distinguish between 150 and 212 F when feeling a pipe. You will

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note that we have removed the covering from all our returns. This is to permit the re-evaporation from the hot condensate to be condensed, and the warm return also gives us some heat in the basement. Our thermometer on the inlet to the vacuum pump shows that the returns at the pump have a temperature of from 150 to 170 F, which is not too hot for the pump to handle without the use of jet water.

"Now here is a thermostatic trap on this drip which I propose to change next Saturday. You will note that this trap—although on an important point dripping the steam main—is located close to the main, which is wrong, as there should be a cooling leg 5 or 6 ft. long ahead of the trap; we have been having some water hammer, as the trap cannot handle the hot water. Instead of installing the cooling leg, which would make this trap operate properly, I am going to put in a small combined float and thermostatic trap which requires no cooling leg.

"Something wrong here," said the inspector, as he found an entrance hall radiator not heating. "The return is cold. I suspect the trap on the radiator is plugged with dirt." He removed the cover of the trap and sure enough found the valve seat covered over with dirt and pipe scale.

As we went on through the plant, the inspector listened to each trap and occasionally, if he heard steam passing through the trap, would shut the radiator supply valve and remove the cover of the trap, and either change the thermostatic element, or clean out the dirt, as the case might be.

When we were on the second floor of the office building, the inspector said, "Now here is a trap in the bookkeeper's office which was blamed for making a rattling noise. Upon investigation, the trouble was found in a trap on the floor above, which discharged into the same return riser. A piece of pipe scale had lodged on the seat of the trap which prevented it from closing tightly, and steam passed into the return riser and backed into this trap, which caused the noise."

How Welds Are Tested

(The Following Describes and Explains the Tests of Oxy-Acetylene Welds Demonstrated by John J. Crowe, A. B. Kinzel† and W. B. Miller† at the 32nd Annual Convention of the International Acetylene Association held in Chicago last month.)*

In general the object of testing is to approximate in the laboratory or in the field the conditions of service. These tests may be divided into two general classifications:

Destructive Tests: Tests wherein the specimen or part is destroyed or rendered unfit for further use.

Non-Destructive Tests: Tests wherein the specimen or part is not destroyed or rendered unfit for further use.

It is obvious that the latter tests are to be preferred where they are applicable and practical considerations permit their use.

I.—Visual Examination

One of the simplest of the non-destructive tests is the visual examination. If this test can be used at the time the weld is being made it has many advantages, if intelligently applied, the principle one being that no apparatus except a pair of dark glasses is required. An important requirement, however, is that the inspector be qualified by experience to properly judge the work being done. He should know by experience whether the proper size of welding tip is being used, whether the flame has been properly adjusted and most important that the welder is obtaining good penetration (good adhesion between the parent metal and the added metal, called the filler material) over the entire area being joined. One of the most predominating faults of welders is the lack of penetration. If proper adhesion is not obtained over the complete area the welded joint will not develop the strength for which it has been designed.

If the adhesion is not carried down to the bottom of the vee, we give rise to the notch effect which may materially reduce the efficiency of the joint.

It is not always possible for the inspector to be present when the welds are being made and this brings up the question: What can an inspector tell as to the quality of the weld by a visual examination? A visual examination in some instances may be misleading, but it unquestionably has a place in the list of tests and if properly applied may be used to advantage.

A good looking weld is not necessarily a good weld, in fact one is inclined to look with suspicion on a puddle weld that has a very smooth level surface or in the case of a ripple weld one that has perfectly spaced ripples—

HEATING PIPE WITH A LARGE FLAME TO TAKE OUT TWIST

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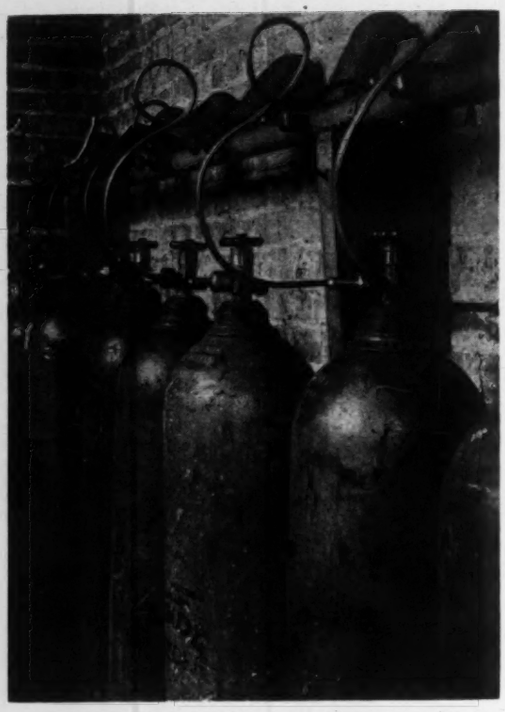
†Engineer, Union Carbide and Carbon Research Laboratories, Inc., New York City.



OXYGEN MANIFOLD IN A PLANT USING OXY-ACETYLENE WELDING IN THE MANUFACTURE OF PIPE

for experience has shown that in many such instances too much time and attention has been given to obtaining a good appearing weld with the result that attention has been diverted from obtaining proper penetration.

On the other hand a visual examination may reveal the lack of proper reinforcement, overflowing of metal without adhesion, burnt or overheated filler metal, and lack of penetration at the bottom of the weld, where it is possible to examine the under side of the weld.

II.—Hammer and Anvil Nick-Break Test

This test consists of rupturing, with a sudden blow, a specimen notched in the weld. It indicates the soundness of the weld by showing on the fractured surface (1) whether complete penetration has been obtained, (2) the presence or absence of oxide or slag inclusions, (3) the degree of porosity, which should not exceed six gas pockets or holes per square inch of the total area of the fractured surface. In a sound weld, the maximum dimension of any pocket should not exceed 1/16 in.

The materials required to make the test are a vise or anvil against which the specimen is clamped; a heavy hammer for applying the blow; and a specimen whose width is $1\frac{1}{2}$ t plus $\frac{1}{4}$ in., slotted at the edges with a hack saw for a depth of not greater than $\frac{1}{4}$ in. No machining is required on the specimen, which is struck in such a way that the notch initiates the fracture. With material $\frac{1}{2}$ in. or greater in thickness, the specimen may be laid on supports about 6 in. apart and struck with a power hammer or falling weight of sufficient intensity to cause sudden fracture. Examination and measurement of the fractured area indicate the proportion, porosity, and absence of oxide or inclusions in the weld.

Although the test is simple it is severe, and only good quality weld metal and welding will pass it. This test constitutes one of the requirements for the qualification test of welders in the new unfired pressure vessel code for Class II vessels.

III.—Free Bend Test for Ductility

The object of the free bend test is to determine the ductility of the weld metal by direct measurement of the elongation of its outside fibers after bending.

The specimen to be tested is punched with gage marks a definite distance apart (never more than 1 in.) and usually within the limits of the weld metal. Next, at one-third its length from each end, initial bends are made. Then it is placed as a strut in a vise, press, or other compression machine and bent until its outside fibers fail. The percentage of elongation of the outside fibers is then measured directly with a flexible scale. The elongation may be calculated, but more accurate results are obtained by direct measurement, since it eliminates errors in calculating the radius of curvature of the bent specimen.

For results in which the values obtained are independent of the thickness of the specimen, the width of the specimen should be at least three times its thickness. The unfired pressure vessel code requires a width of $1\frac{1}{2}t$. The corners of the specimen should be rounded to $\frac{1}{8}$ or 1/10 t. The length is unimportant provided it is sufficient for the test to be carried out. The outside surface should be smooth and free from local defects, which would adversely affect the test; viz., transverse scratches, etc. The gage length may vary without affecting the accuracy of the test. In bending, corner cracks are not considered as failures, nor are surface defects unless their greater dimensions exceed 1/16 in.

This type of ductility test is believed to be superior to that made by tensile tests on welded coupons, a method which is of little value due to the non-homogeneity of a welded test piece, particularly when the weld is stronger than the base metal.

The free bend test also is superior to the methods formerly used, in which the angle of bend was measured. The angle of bend is no criterion of the ductility of the weld metal, because several angles of bend may result in the same elongation or stretch of the weld metal. The measurement of outside fiber elongation yields comparative results and affords an accurate and simple test for ductility.

The free bend test is widely used both in this country and in other countries. The unfired pressure vessel code requires a bend elongation of 15 per cent for gas welds and 20 per cent for electric welds. The Swiss government uses this method in testing the steel for oxygen and acetylene cylinders.

IV.—Tension Test

The object of the tension or tensile test is to determine the strength of a welded specimen by pulling it until either the weld or the base metal breaks. Since one of the most important properties of a weld is its strength, tensile testing is widely used in industry, both as a means of determining the strength of the weld and of determining the ability of the welder. When a specimen breaks outside the weld, it means that as far as straight static loading is concerned, failure never will take place in the welded joint.

V.—Hardness Tests

The hardness test, as usually applied, is a non-destructive test and while it has an important place in laboratory testing because of the ease with which the test may be applied it is not used to a great extent as an inspection tool in the field.

There are many methods of determining hardness, the simplest being the file test. By running a file over the piece to be tested information may be obtained as to whether the material is harder or softer than the file and in some degree the hardness as compared with other specimens subjected to the same treatment. In testing with the file it is essential that a standard file be used and much depends on the manner in which the test is applied.

In the laboratory, recourse is had to more accurate means. Machines in general favor for this purpose are the Brinell and Rockwell. Both of these measure the power of the metal to resist local displacement.

Brinell Tests: In the Brinell tests the specimen is mounted on an anvil and a pressure of 3000 kilograms (6620 lb.) is applied against the specimen through the medium of a hardened steel ball 10 mm. (0.4 in.) in diameter. After allowing the load to remain for a period of one-half minute the pressure is released and the depth to which the 10-mm. ball has indented or penetrated the specimen is measured. The results are expressed in Brinell numbers obtained by applying the formula:

$$\text{Hardness number} = \frac{L}{A} \times \sqrt{p}$$

where L = load in kilograms; A = superficial area of concave surface; and p = radius of ball.

Rockwell Tests: The principle of the Rockwell hardness tester is practically the same as that of the Brinell tester, but differs from the Brinell in that a lesser load is used on a smaller ball or cone-shaped diamond; the depth of indentation is measured and indicated on a dial attached to the machine. The hardness is expressed in arbitrary figures called Rockwell numbers which are prefixed with a notation to indicate the size of ball, load, and scale used.

As stated before, hardness determinations are logically for the laboratory and are mostly used in development of filler materials. The fact that one deposit made with the oxy-acetylene torch is harder than another is of itself no indication that it will be stronger or wear better than the other. The test is often used for control after the proper value of hardness of a specific material for a specific purpose has been determined.

VI.—Specific Gravity

Specific Gravity—The specific gravity of a solid is the ratio of the mass of the body to the mass of an equal volume of water at some standard temperature. *Density*—The density of a body is its mass per unit volume.

If the gram is used as the unit of mass and the milliliter as the unit of the volume, the figures representing the density are the same as the specific gravity of the body referred to water at 4 degrees Centigrade as unity.

Until recently the determination of specific gravities or densities was confined largely to the chemical and physical laboratories, but recently welding engineers are using them as a means of determining the quality or soundness of weld metal.

The *American Society of Mechanical Engineers* in its rules for the construction of unfired pressure vessels, section VIII of the *A.S.M.E. Boiler Construction Code*, in paragraph U-67—'g' states that specimens taken from the weld metal of the joints shall have a minimum specific gravity of 7.80, which means that the specimen shall weigh 7.80 times the weight of an equal volume of water at 4 C.

Various handbooks give the density of pure iron as 7.85 to 7.88 and of steel as 7.60 to 7.90. The density of iron oxide is less than 6.0 and the density of air is only 0.0013. From this it is obvious that if the weld has been contaminated by appreciable quantities of iron oxide and/or contains air or gas pockets the specific gravity or density will be reduced well below the value of 7.80 specified by the *A.S.M.E.* as the minimum.

A simple method of making this test is to prepare a specimen ⅝ in. in diameter by 2 in. long (as called for by the code) and weigh the specimen on an analytical balance. Knowing the volume and the weight, the density may be computed.

VII.—Stethoscope Test

The object of the stethoscope test is to determine, by means of the sound a weld gives when tapped with a hammer, whether the weld metal is sound or has cracks or holes. Just as a bronze bell rings clear and a cracked bell has a shrill, reedy note, so good weld metal gives a ringing sound and poor metal a characteristic, flat sound.

In order more readily to identify these sounds, an ordinary physician's stethoscope is used for listening, the only extra precaution being to cap it with a soft rubber cap, to prevent the application of the stethoscope to the metal from affecting the sound produced.

The stethoscope test has been applied successfully to pressure vessels, tanks, and buildings. It is particularly

Welding a Pipe Line with the Oxy-Acetylene Process

applicable as a non-destructive method suitable for testing fillet welds.

VIII.—Invisible Ray Tests

X-Ray Tests: Metals can be x-rayed and their internal defects made clearly visible on photographic plates. If inside a weld there are cracks, holes, or general porosity, the x-ray photograph will reveal the condition.

The method is simple and consists of placing an x-ray tube on one side of the object and a photographic plate on the other. After proper exposure—usually from one to fifteen minutes, depending upon the thickness of the material—the plate is developed and examined for defects in the weld.

This method has found wide industrial use and is recognized as one of the foremost of non-destructive tests.

Gamma Ray Test: Newer than, but similar in method to, x-ray tests, are gamma-ray tests. The gamma ray, emanating from radium, penetrates the metal more quickly. For testing heavy work, which would require impracticably long x-ray exposures, or for speeding up tests on ordinary material, the gamma ray is extremely useful. On very heavy work, an overnight exposure to gamma rays is usually made.

IX.—Compression and Drift Tests

The value of bend tests and tensile tests has been explained and, while such tests may be used for evaluating the properties of welds, it is not always possible to obtain specimens which permit of the testing being done in the manner which has been described.

Three years ago, J. L. Anderson,[1] described the manufacture of tubing by the oxy-acetylene process. To obtain specimens from such tubing for tensile testing is impracticable.

Drift Test: A simple test has been developed for the testing of such tubing which gives not only a measure of the tensile strength of the weld as compared with the parent metal, but a measure of the ductility. The test consists of forcing a tapered, hardened steel drift into one end of the tube. The drift may be driven in with a hammer or forced in with a testing machine which has been improvised from a hydraulic jack. If failure occurs outside of the welded area, we know that the welded joint is stronger than the parent metal. The distance the drift is forced into the tubing before failure is a measure of the ductility.

Crush Test: If a short length of tubing has a sufficient load applied axially, the tubing will collapse like a bellows, and in so doing the weld will be subjected to tensile stresses on both the top of the weld and the under side of the weld, and also in a longitudinal and transverse direction.

This is also a qualitative test as to ductility and an excellent means of evaluation as to what degree the tubing will stand flanging operations.

X.—Hydrostatic Tests

In design of pressure vessels the engineer may compute very carefully the stresses in the various parts of the vessel and design accordingly and to insure satisfactory welding the operator may be qualified before and after the job, observed while welding, and coupons may be selected at random and cut from the vessel under construction and tested as to strength. All of these precautions are desirable and should be taken on an important job, but the most satisfying test of all is to witness a hydrostatic test in which an internal pressure of 1½, 2 or even 3 times the designed working pressure is applied. This test eliminates any doubts as to whether the correct formulas have been used in computing the stresses and furnishes an excellent means of detecting porous metal, not only in the welds, but in the parent metal.

It is desirable in all cases, and required by statute in many instances, that all welding done on pressure vessels be in accordance with the requirements of certain well recognized codes.

Pipe lines, such as are used in the oil fields for conveying oil and gas under pressure, may be classed as pressure vessels, and for the testing of such lines the hydrostatic test has proven very valuable. In some cases the pipe lines are filled with air under pressure and each and every welded joint is examined for leaks by covering the joint with soapy water. The leak will, of course, be revealed by the formation of a soap bubble. In other cases an internal water pressure of several times the working pressure is applied and the joints examined, while under pressure, for leaks.

In welding cylindrical pressure vessels it should be remembered that the forces tending to cause failure of a longitudinal joint, that is, the joint running lengthwise of the vessel, are twice as great as the forces tending to cause failure of the circumferential joint, that is, the joint running around the circumference of the vessel, and for this reason great care should be exercised in making longitudinal joints.

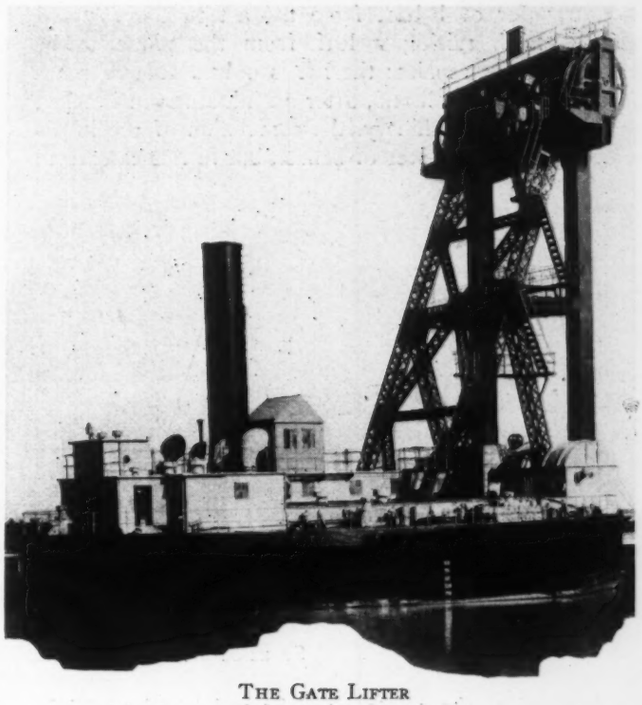
One of the exercises employed in training of welders is to require the welder to construct a box with a nipple in one end. This is then tested by the application of internal pressure. If the welding has been properly done, the sides and bottom of the box should round out and form a bottle before failure of the welded seams takes place.

[1] Development and Progress of Mechanical Gas Welding, by J. L. Anderson. Proceedings, *International Acetylene Association*, 1928.

Bevelling with the Torch

By C. G. Moon

In order that the steel gates for the locks in the Welland ship canal may be replaced if damaged or when repairs are necessary a gate lifter of novel design is provided. The method of operation and the piping arrangements of the lifter are described in this article



THE GATE LIFTER

Piping Arrangements in a "Gate Lifter"

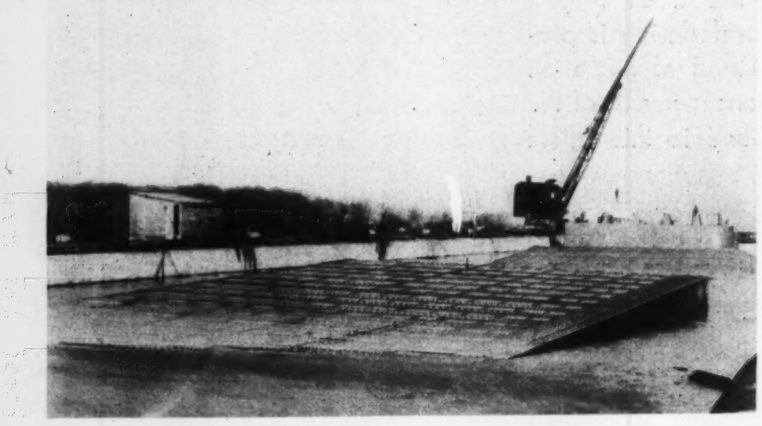
TEN MILES west of Niagara Falls, the Dominion of Canada has completed the Welland ship canal at a cost of more than $120,000,000, forming an important link in the Great Lakes-St. Lawrence waterway. The channel has a bottom width of 200 ft. and each of the seven lift locks has a depth of 30 ft., a width of 80 ft. and a usable length of 820 ft., and thus they are capable of accommodating practically any type of vessel except the very largest ocean liners and a few of the heavier and wider battleships. The upper and lower service gates are respectively 35 ft. 6 in. and 82 ft. 0 in. high.

Function of Gate Lifter

Lake Erie is 326 ft. higher than Lake Ontario and 46½ ft. is the average lift of each of the locks, a somewhat greater lift than anything which has been heretofore attempted, thus giving rise to many problems of interest to hydraulic engineers. In order that the steel gates for these locks may be replaced if damaged or when repairs are necessary, a floating derrick of novel design was built and it is the purpose of this article to describe something of the piping system installed therein.

There are three major conditions to be taken into consideration in operating. *First,* hoisting a damaged gate leaf from the bottom of the canal, when divers are sent down to hitch the two outer hangers to the leaf and the hoist is made to water level; the two inner hangers are then attached and the leaf is hoisted to the masthead in which position it is conveyed to the dry dock. *Second,* hoisting a floating leaf to the masthead and

lowering it into place; this operation requires slow and careful handling in order that the hemispherical pintle upon which the leaf rests may not be damaged—the last foot of this lowering will probably be accomplished by a transfer of ballast from the aft to the forward tanks. *Third,* raising a leaf from the pintle to be taken away for repairs; the lift is only a foot or so to clear the concrete sill and, after an initial strain is taken by the hoisting machinery, the completion of the lift is performed by a transfer of ballast, but in this case from the forward to the aft tanks. The weight of an 82-ft. gate leaf is approximately 480 tons in the dry and the peculiar shape of the gate lifter is due to the necessity for maneuvering in one of the lock chambers and swinging to remove or replace any gate leaf.



Spare 82-Ft. Gate Leaf Floating in Horizontal Position

Piping Arrangements

There are 44,500 lb. of piping installed on the gate lifter ranging in diameter from ½ in. to 10 in., and including steam pipes, drain pipes, fuel oil feeders and vapor vents, scupper pipes, water ballast transfer pipes and the high pressure feeders for the equalizing cylinder system.

Three pumps, driven by 16-b.hp. direct-connected motors at 1,150 r.p.m., were installed to shift the water ballast which counterbalances the weight of the gate leaf. The longest pipe line is some 110 ft. and contains various bends and fittings equivalent to about 390 ft. extra length, or a total of 500 ft. of straight pipe. The specifications called for a transfer capacity of 710 g.p.m. against a head of 40 ft., the object being to insure that the total time in pumping would be 30 minutes or less, and the rate of transfer about double that or the hoisting, which is 60 minutes for the full travel of 90 ft.

Forward ballast tanks have a depth of 13 ft., whereas the after tanks are 25 ft. deep, so that the transfer time aft is the governing feature. Static head ranges from + 13 ft. to — 25 ft., and the friction head, figured by Weisbach's formula, is about 30 ft. for 6-in. pipes where it is only about half that for 7-in. pipes. The velocity in the 6-in. pipes at 710 g.p.m. is 576 f.p.m., which is slightly over the 500 f.p.m. which good practice allows.

The pump characteristics show that even this velocity might be exceeded at the low static heads; therefore a decision was made to make the fore and aft pipe lines 7 in. in diameter and the thwartship line 4 in. in diameter. Bend radii were lengthened whenever possible and flat non-return check valves were used, thus reducing the frictional losses to a minimum. These checks valves seal the discharge, regardless of the water remaining in the pumps, and thereby enable the air exhausting pumps to create a vacuum in the suctoin system to prime the pumps.

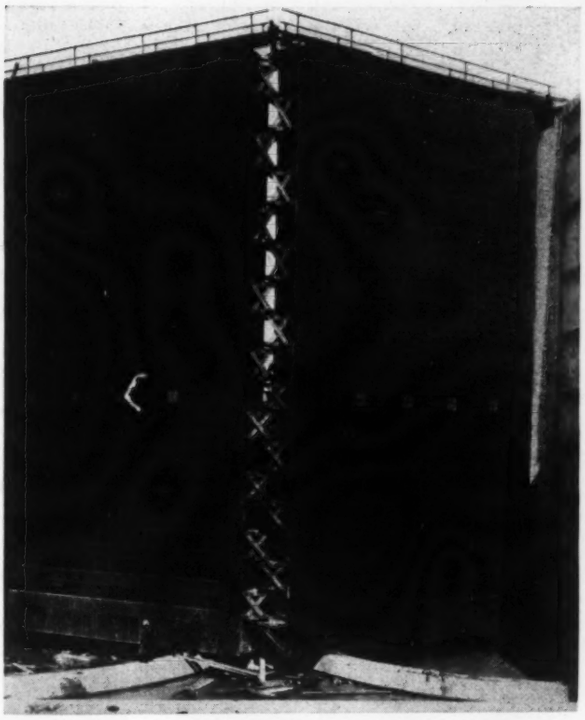
The calculated effect of using the large diameters is to decrease the fore and aft transfer time by about five minutes. This decrease is of most importance when lifting a gate leaf from its hinges.

The double action of the manifold valves allows the pump to rotate always in the same direction while, by depressing one valve, water is directed to the forward tanks and by depressing the other valve the flow is reversed to the after tanks. Each manifold is operated by means of a 1-hp. motor through a worm wheel and gear—the operating switches are mounted in the control room on the upper deck.

Equalizing System of Piping

Design pressure in the equalizing system was 2,000 lb. per sq. in. The high pressure pipes are 1½-in. with couplings 7-in. O.D.X 1½ in. thick carrying four 1-in. bolts and provided with lead washers 1/16-in. thick. The low pressure return pipes are standard black steel.

The equalizing system consists of a 165-gal. storage tank carrying an anti-freeze solution of glycerine and water, and a 1⅞-ft. by 6-in. single acting triplex plunger pump having a capacity of eight Imperial gallons per minute against a pressure of 2,000 lb. per sq. in. and geared to be operated by a 20-hp. motor operating at 1,150 r.p.m.—these are located in the forward hold. The four equalizing cylinders which anchor the hoisting cables, are above and forward of the pump, on the intermediate deck. In the control house, on the upper deck, is the manifold and four indicating lights for each cylinder. The equalizing plungers and attached anchor sheaves have an extreme travel, fore and aft, of 3 ft. 9 in. and, by means of electrical contacts, actuate the lights. Thus the operator can tell the approximate position of each plunger at all times. The safety range of 3 ft. is indicated by two intermediate lights showing brightly; if the lower light of any row burns bright then



A View of the Completed Lower 82-Ft. Service Gates

that cylinder requires filling and when an upper light brightens the corresponding cylinder is filled to capacity.

The filling main from the pump is provided with a check valve and an automatic relief valve which is set at 5 per cent more than the extreme working pressure and allows all cylinder valves to be closed, in which case the discharge is by-passed back into the storage tank. This working pressure is about 1,680 lb. per sq. in. The feed main is carried directly from the pump to the manifold in the control house from which individual pipes lead to each cylinder. With all valves open the pump will fill all cylinders and the pressure in all cylinders is equal; by closing one, two or three valves, any cylinder or combination of cylinders may be filled or held at varying pressures. From each cylinder there is a return ½-in. high pressure overflow pipe with check valve to the control house having a visual overflow into a pan which in turn is drained back to the storage tank. Thus no damage can be done to the system even if the pump is left running. As a further safety precaution the pressure gage on each unit is electrically connected with the main screw drive motors so that a 3 per cent excess of pressure immediately cuts off the power from all motors when they are clutched together or from the individual motor connected to that unit if it is working independently.

In operation, the four filling valves and four vent valves are opened and the pump is started. The indicating lights glow brightly in turn until the upper lights show that all cylinders are full and the plungers are bearing against the forward stops. Then as soon as the liquid flows from the overflow pipes the vent valves may be closed. The pump is then stopped and the system is ready for hoisting.

A preliminary hoist is taken with the pressure in all four cylinders equalized, or may be taken by any one unit or two units connected. The valves separating the two port and the two starboard cylinders are then closed and as the hoist is continued the pressure on the two pairs becomes unequal, owing to the fact that the miter end of the leaf is heavier than the quoin end. With the full weight of a damaged 82-ft. gate leaf suspended, the respective pressures are about 1,680 lb. and 1,340 lb. or the heavier side is about 25 per cent in excess of the lighter and the gage pressures are about 12½ lb. per ton lifted at each yoke.

The four pressure gages, with their electric cut-outs, are arranged in full view of the operator in the control room and are directly connected to the manifold with ½-in. piping. Each equalizing cylinder can be drained by gravity through a 1½-in. low pressure return line with a filter into the storage tank.

Much study was given to the design and construction of the manifold for this system. A pressure of 2,000 lb. induces stresses which were not easily calculable in such a complicated structure. The manifold was constructed in two parts with a base slab of forged steel and the upper interconnecting elbows of cast steel spaced by the bronze valves, the whole bolted together with flanged fittings and lead gaskets.

Amount of Oil Lost Due to Small Leaks

One Drop Per Second

1 minute loss is 0.1 ounce; 1 hour loss is 6 ounces; 1 day loss is 1 gallon and 1 pint; 1 week loss is 8 gallons; 1 month loss is 34 gallons.

Two Drops Per Second

1 minute loss is 1/3 ounce; 1 hour loss is 20 ounces; 1 day loss is 3 2/3 gallons; 1 week loss is 26 gallons; 1 month loss is 2 barrels.

Drop Breaking to Stream

1 minute loss is 2 ounces; 1 hour loss is 1 gallon; 1 day loss is 24 gallons; 1 week loss is 3½ barrels; 1 month loss is 14 barrels.

1/16-in. Stream

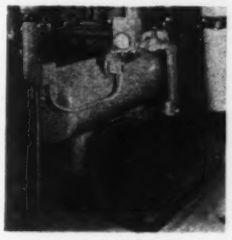
1 minute loss is 7½ ounces; 1 hour loss is 3½ gallons; 1 day loss is 84 gallons; 1 week loss is 11½ barrels; 1 month loss is 50 barrels.

⅛-in. Stream

1 minute loss is 23 ounces; 1 hour loss is 11 gallons; 1 day loss is 260 gallons; 1 week loss is 36 barrels; 1 month loss is 156 barrels.

¼-in. Stream

1 minute loss is 83 ounces; 1 hour loss is 39 gallons; 1 day loss is 18½ barrels; 1 week loss is 130 barrels; 1 month loss is 555 barrels. —*F. E. W.*



INSTALLATION OF A MECHANICAL FORCE-FEED LUBRICATOR ON A FOUR-CYLINDER VERTICAL ENGINE

Oil in exhaust steam used for heating or process work forms a film on heat transfer surfaces and cuts down the amount of heat transmitted materially. In order to insure the efficiency of such equipment it is necessary that the prime mover and auxiliaries be lubricated by a correct oil, applied in the proper manner. This article points out the factors involved and shows the importance of studying the method of lubrication where exhaust steam is used for heating or process.

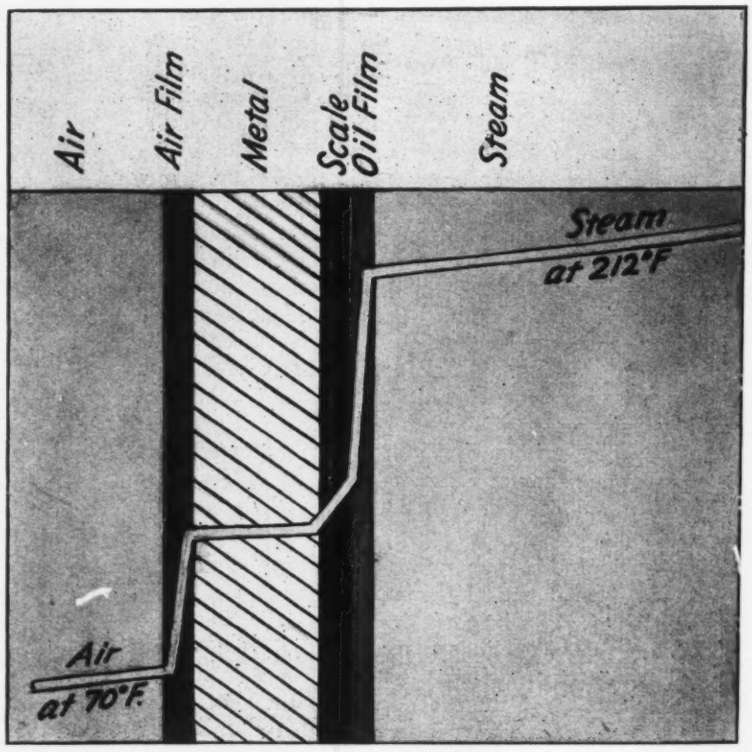


FIG. 1—SKETCH SHOWING THE TEMPERATURE GRADIENT FROM STEAM IN A RADIATOR TO AIR IN A ROOM

Oil In Exhaust Steam Reduces Heat Transfer

By R. P. Tobin*

WHEN exhaust steam or condensate is used for heating purposes, oil present in the steam is generally objectionable because of its tendency to foul radiators, pipes, heating coils, feed water heaters and other equipment. In the case of heat exchangers, the rate of heat transfer from the heat carrying medium on one side of the tube or section to the heat receiving medium on the other side, is very materially affected by the presence of an oil film on the surface which imposes an insulating wall between the steam and the air, water, or other liquids to be heated.

Effects on Heat Transfer

Take as an example, a radiator and consider a partial longitudinal section as shown in Fig. 1. The heat transferred from the steam to the air may be conceived of as occurring in five steps as follows:

From the steam itself to a very thin, slow moving film composed of water and oil.

From the slowly moving film to an oily deposit or scale attached to the inner wall of the radiator.

From the oily deposit or scale to the metal wall of the section.

From the wall of the radiator to a very thin, almost static, film of air on the outside wall of the section.

From the thin film of static air to the surrounding more or less turbulent air in the room.

Rate of Heat Transfer

Each of these steps interposes resistance to heat transfer. The rate of heat transfer (Btu per square foot of surface per degree difference in temperature per hour) is generally spoken of as the *coefficient of heat transfer* or the conductance and is usually represented by K.

$$K = \frac{970 \times (\text{lb. of steam condensed per hour})}{(T_1 - T_2) \times (\text{area of surface in sq. ft.})}$$

And the amount of heat transferred in h hours is $Q = K\ A\ h\ (T_1 - T_2)$, where A is the area of the heat transfer surface in sq. ft. and $(T_1 - T_2)$ is the mean temperature difference between opposite sides of this surface. The amount of heat transferred through the wall of the section is approximately 970 times the pounds of steam condensed, 970 being the Btu's given up by a pound of steam when condensed (approx.).

* Chief engineer, Vacuum Oil Company, Inc., New York City.

Many attempts have been made to develop equations for predicting the value of K from the physical properties of the substance, the configuration of the apparatus, and the mean velocity of the fluid passing the heat transfer surface. So far, no satisfactory equation has been devised, and in consequence, experimental values must be relied upon. This coefficient is governed not only by the above-named factors, but also by the nature of the substances through which the heat flows. The thermal resistance offered by the composite substance is the reciprocal of K $(R = 1/K)$, and is equal to the sum of the individual resistances.

In this paper, no attempt will be made to discuss the various theories relative to the transfer of heat through the steam itself, or the resistance offered by the air film and cast iron wall. We are mainly concerned with the oily film and the deposit or scale.

Film Resistance

The resistance of a film of hot gas—such as surrounds boiler tubes—is exceedingly high. It has been estimated that in certain cases 98 per cent of the available temperature drop is required to force the heat through such a film. In the case of a film composed largely of water, the resistance is smaller. The resistance of an oily film depends mainly upon the percentage of oil present in the film. The conductivity of water is approximately four times that of oil. The higher the percentage of oil, the greater is the resistance. In both water and oil, the conductivity varies with temperature, increasing as temperature increases.

The thermal resistance of the oily film can be determined only by experiment for any given set of conditions. The author does not know of any experimental data giving values of resistances for oily films for various temperature conditions and percentages of oil present. In general it is recognized, however, that the resistance is greatly increased by the presence of oil and that this oily film offers a considerable amount of the total resistance.

Oily Deposit or Scale

The effect of the oily deposit or scale is the same as increasing the thickness of the metal wall of the sec-

tion. This scale, however, offers a considerably greater resistance to heat flow per unit of thickness than cast iron or other metals.

The true nature of the transfer depends largely upon the chemical and physical characteristics of the scale, which vary over a wide range. However, oil, silica, iron oxide, calcium carbonate, calcium sulphate, magnesium carbonate and other substances are usually present. The exact constituents depend upon the composition of

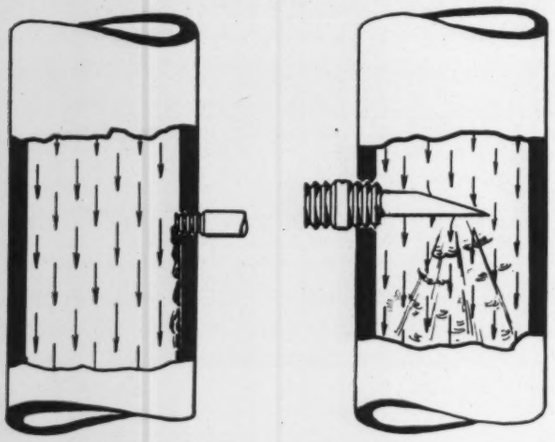


FIG. 2A (LEFT)—SIMPLE INJECTION

The oil is injected into one side of the steam pipe and runs down the inside wall as shown. A small percentage is atomized, a greater part being wasted. A large quantity of oil is therefore required to obtain sufficient distribution. The result is a large amount of oil in the exhaust steam.

FIG. 2B (RIGHT)—ATOMIZATION

The illustration shows the atomizer carrying the oil to the center of the steam pipe where it is broken up into a fine spray, and distributed throughout the steam. Thus, the oil is effectively used, and a small quantity of the correct oil provides efficient lubrication with minimum oil in the exhaust steam.

the water from which the steam is generated and upon the amount and character of the oil. This scale is usually of a spongy nature and is less conducive to heat transfer than a solid, stone-like scale.

The resistance to heat transfer through this scale depends mainly upon the nature of its molecular structure. As the molecular structure varies widely, so does the thermal resistance. Data are lacking as to the thermal properties of scales of this kind; however, it is generally known that they offer very great resistance to heat flow.

Prevention of Contamination

While a large amount of desirable data are lacking, this preliminary discussion shows the very important fact that resistance to heat transfer is greatly increased by the presence of oil films and deposits upon the heat transfer surfaces. The extent of such contamination may be minimized by:

A reduction in the amount of oil used for the lubrication of the cylinder and valve of the engine.

Removal of oil from the exhaust steam or condensate by means of a suitable device.

As prevention is better, in general, than cure, the first method is to be preferred. It can be accomplished only, however, by the adoption of a lubrication practice which insures a minimum feed of cylinder oil. A very small feed of high quality oil manufactured to meet specific service conditions will provide adequate lubrication if it is properly applied. It is not uncommon to find it possible to reduce the feed by a half when correctly selected high grade oil is substituted for ordinary oil of inferior quality.

Correctly selected oil for the lubrication of steam cylinders minimizes wear, steam leakage and consequent power losses. Such oil must have fluidity that will permit ready distribution. Its film strength must be adequate for proper piston seal and effective lubrication. Compounding is required because of the washing effect of the moisture in the steam. Economical feeds, which are so essential to oil-free exhaust, are obtained only by the use of high quality oil.

Range of Conditions Involves Careful Oil Selection

The range of conditions that must be met are so varied that selection of a steam cylinder oil should be from a group of several oils.

Superheated steam. The higher the temperature the greater the thinning effect on the oil films covering the cylinder wall and valve surfaces. And, the more oil is heated, the greater is the tendency for it to form objectionable carbon deposits. The correct cylinder oil must then be one of sufficient body and film strength and one free from carbon forming tendencies.

Low pressure steam, because of its low temperature and relatively low activity, is a weak distributing agent, requiring oil correspondingly light in body but of high film strength.

Wet steam has a severe washing effect, that necessitates an unusual amount of compounding.

Light loads require light oil because the volume of the steam in the cylinder is small and its distributing power is low.

Large cylinders are relatively hotter than small cylinders and require oil of relatively heavy body.

High speed engines give little time per stroke for complete film distribution, and the quick-acting property of a light bodied oil is necessary.

Method of Application Important

The method of application is of importance. Uniformity and reliability of feed are essential characteristics of any device employed for applying oils to any machine. In the case of steam engines, oils are generally applied to the cylinders and valves by means of either a mechanical force-feed lubricator or a hydrostatic lubricator.

Three general methods are practiced to apply oil to the valves and cylinders of steam engines. These are:

Direct application to the cylinder and valve.

Simple injection into the steam pipe or steam chest without atomization (see Fig. 2).

Injection into the steam pipe in conjunction with an atomizer (see Fig. 3).

Direct Application

In direct application, the moving parts are depended upon to distribute the oil over the frictional surfaces. Obviously, to effect thorough lubrication, oil must be ap-

plied at numerous points; otherwise, considerable quantities will be necessary to insure thorough distribution to all frictional surfaces with consequent increase of oil in the exhaust.

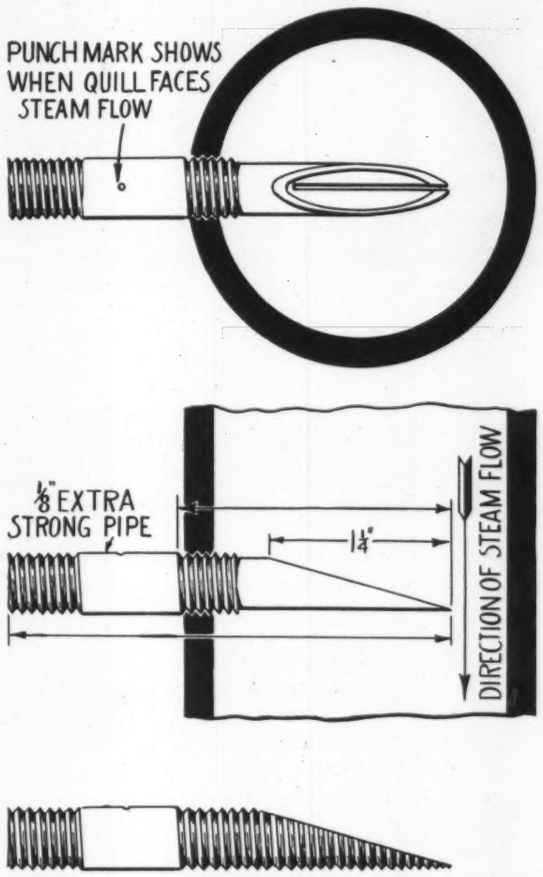


FIG. 3—TWO AND THREE-PIECE ATOMIZERS. CARE SHOULD BE TAKEN TO LOCATE THE CENTER OF THE CUT-AWAY PORTION AT THE CENTER OF THE STEAM PIPE AND FACING THE STEAM FLOW

In under-loaded engines (less than 75 per cent of rated capacity), where atomiziation is not thorough due to low steam activity, it is sometimes better to apply oil directly to the cylinders and valves. In the case of the uniflow engine, oil is often applied directly to avoid trapping it in the steam jacketed cylinder heads. Oil application direct to the cylinder is also practiced with highly superheated steam because of the influence of high temperature on oil in the atomized condition.

Simple Injection

Injection of the oil into a steam pipe or steam chest without atomization does not insure the steam becoming thoroughly impregnated with oil. Therefore, complete distribution over the frictional surfaces is not always assured. If the pipe employed to introduce the oil just penetrates the wall of the steam pipe, the oil will not be atomized and may run down the inside wall and enter the cylinder in relatively large drops, as shown at the left in Fig. 2. This method requires a relatively large feed in order to insure thorough distribution with a resulting increase in amount of oil in the exhaust.

Injection with Atomizer

Injection into the center of the steam pipe through a suitable atomizer is illustrated in Fig. 2. Atomization of the oil is accomplished by the impact of steam, which blasts the oil through slots cut in the atomizer quill. In this way the oil is heated in the atomizer, rendered more fluid, and is thoroughly atomized and mixed with the steam. It is thus carried by the steam to all internal frictional surfaces of the engine.

With atomization, efficient lubrication is obtainable with minimum feed and a consequent reduction in the amount of oil in the exhaust. By using a high grade oil correctly selected for the service by carefully regulating the feed and by the use of an atomizer in conjunction with a mechanical force-feed lubricator, the amount of oil in the exhaust can in general be reduced to a point where it is no longer a factor.

Removal of Oil from Exhaust Steam

While in practically all cases the oil in the exhaust steam can be controlled by the use of the correct oil applied in a proper manner with a careful regulation of the feed, it is advisable to install a suitable oil separator as a precautionary measure. If the separator is correctly designed for the service and properly installed—and with the correct oil in service—the oil will be removed so effectively that the condensate can be used for cooking, dyeing, washing, ice making, or boiler feed without further treatment. Within reason, the separator should be placed as far from the engine as possible to insure efficient separation.

The effectiveness of any heating or process system employing exhaust steam can be increased by the correct lubrication of the prime mover and the auxiliaries supplying the steam. This involves the proper selection of the correct oil, and its proper application.

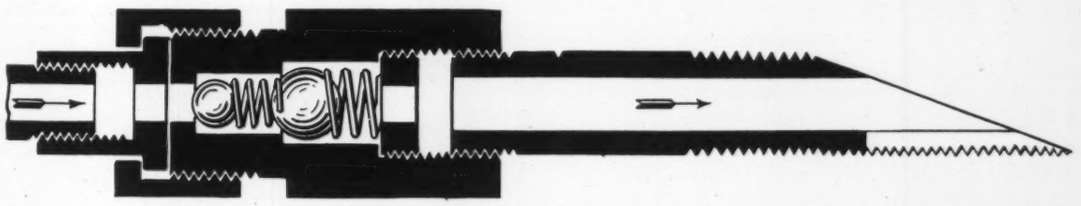
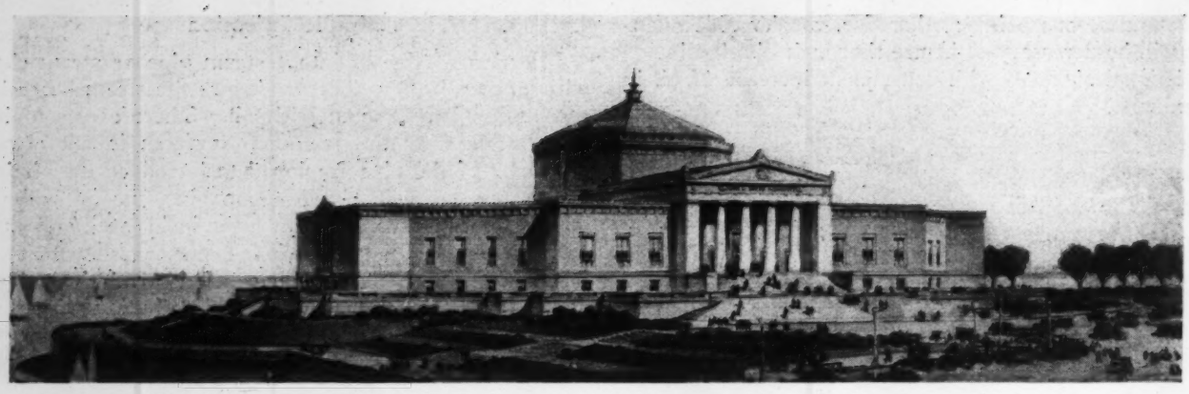


FIG. 4—BALL CHECK VALVE AND ATOMIZER. IT IS ADVISABLE TO INSTALL A CHECK VALVE AT THE EXTREME END OF THE OIL DELIVERY LINE, REMOTE FROM THE LUBRICATOR. THIS WILL MAKE CERTAIN THAT THE PIPE IS AT ALL TIMES COMPLETELY FILLED, WHICH INSURES THAT OIL IS AVAILABLE IMMEDIATELY THE ENGINE STARTS, AND ALSO PREVENTS THE STEAM FROM BACKING INTO THE OIL LINE



THE JOHN G. SHEDD AQUARIUM, ON CHICAGO'S LAKE-FRONT, WHICH HOUSES MANY VALUABLE SPECIMENS IN "CONDITIONED WATER"

Water Supply for an Aquarium

Pumping Equipment in the Shedd Aquarium

THE John G. Shedd aquarium in Chicago houses both salt and fresh water fish, inhabitants of waters from the tropics to the arctic. Fresh water from Lake Michigan is pumped by two bronze, vertical, submerged pumps driven by two 10-hp., 1800-r.p.m. motors and flows to a tank located under the roof at the highest point of the building. These pumps are controlled by a float switch located in the tank. Water from this tank flows by gravity to be used for such purposes as heating, cleaning and sanitary supply, but not for drinking or supplying the fish.

Two large all-bronze, submerged, vertical pumps, driven by two 30-hp. motors, take water from the lake and put it in a one-million-gallon concrete tank located in the basement, to be used for the fresh water fish and for the cooling equipment. Part of this fresh water is pumped through the cooling equipment and into the fish tank by three 2-in. pumps with monel metal shafts driven by 5-hp. motors. This water is used for supplying fresh water fish requiring very cold water.

Three similar pumps are used for circulating natural fresh water except that they deliver twice the above amount of water and are driven by 7½-hp. motors. This water is used for supplying fish from temperate climates.

Tropical salt water fish are supplied with heated salt water circulated by three 2-in. pumps constructed of aluminum bronze alloy with monel metal shafts, resistant to the corrosive action of salt water.

Three similar pumps of smaller capacity, being direct connected to 5-hp., 1800-r.p.m. motors, supply cold salt water to specimens from colder regions. This water passes through a cooler where it is brought down to the required temperature.

It is interesting to note in this connection that salt water for fish cannot successfully be made synthetically, but must be brought from the ocean in tank cars. Even an aquarium such as the one in New York cannot use the water directly from the harbor, but must bring it in from considerable distances. However, after the original supply of salt water once was obtained, it will never be necessary to replenish it in the John G. Shedd aquarium, as the addition of the water in which new specimens are brought takes care of all losses, and evaporation is taken care of by the addition of filtered fresh water. By means of circulation, aeration and a one-million-gallon reservoir, which acts as a settling basin, the water is kept in the proper condition.

All the above pumps are in batteries of three each with two of the pumps operating constantly and one in reserve. This is necessary as a failure in the circulating system would soon kill specimens worth thousands of dollars. As an insurance against power failure, there are four lines entering the building so that if half the power stations in Chicago were put out of commission, electricity still would be available from the remaining plants.

An artificial water fall is made in one of the tropical pools and the water is circulated by means of a 1½-in. pump direct connected to a ½-hp. motor operating at 1200 r.p.m. The head under which this pump operates is very slight in order to give the appearance of water naturally rising from a spring.

Water for human consumption in the aquarium is supplied by two 1½-in. pumps operated by two 7½-hp. 3600-r.p.m. motors, taking water from the city mains from zero to a few pounds suction head and putting it into a 1500-gallon pressure tank under a maximum head of 60 lb. A small compressor driven by a ½-hp. motor replenishes the air in the tank. City water could not be used for the fish because of the chemicals used in the purifying process.

Two 900-r.p.m., 7½-hp. motors drive two air compressors to supply air to the fish tanks. All motors used have special moisture proof windings.

Heating·Piping
and Air Conditioning

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Acoustical Problems in the Heating and Ventilating of Buildings

By Vern O. Knudsen[1], Ph. D., West Los Angeles, Calif.
NON-MEMBER

IT IS not improbable that the physical constituents of our next era of prosperity will include (1) developments in the air conditioning and the mechanical refrigeration of buildings, and (2) the abatement of noise in buildings and out of doors. The problem of noise abatement is destined to become more and more closely associated with the problem of the air conditioning of buildings.

The public has become noise conscious, and is directing an effective attack upon all unnecessary noise. Thus, New York City has an active Noise Abatement Commission which has already made an extensive survey of noise in the streets and in the buildings of New York City. Campaigns are being instituted against the worst noise nuisances such as motor trucks, street railways and automobile horns. Boston and Chicago also are organizing campaigns against noise, and other cities are planning to take steps in the same direction. Manufacturers and distributors of acoustical materials are installing sound-absorptive tiles, felts and plasters in all types of commercial buildings for the purpose of reducing noise. Investigations and researches by efficiency experts of leading corporations, by health authorities, and by life insurance agencies are demonstrating that noise is exacting a heavy toll in the reduced output of all types of workers, in worn and shattered nerves, and in a shortening of the average span of life. The reduction and suppression of noise is a necessary antidote for the machine age in which we are living.

This campaign against noise is of considerable moment to the heating, ventilating and refrigerating industries. In the first place, the equipment used for heating, ventilating and refrigerating is not free from offense as a source of noise; and in the second place, the elimination of noise in many buildings will require that the buildings be air conditioned in order to prevent the transmission of noise through open windows, which at present is the most troublesome source of noise in buildings. It is obvious therefore that the heating and ventilating engineer and the acoustical engineer will have many overlapping problems during the next two or three decades. It is therefore very much in the interest of the heating and ventilating engineer to gain a working knowledge of the basic facts of architectural acoustics. It is the purpose of the present paper to set forth certain of these facts which should be serviceable to all heating and ventilating engineers.

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For presentation at the 38th Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Cleveland, Ohio, January, 1932.

Requirements for Good Hearing in Interiors

The requirements for good hearing in any architectural interior are the following:

1. The sound, whether speech or music, should have an adequate loudness in all parts of the room.
2. The sound energy should be distributed uniformly in all parts of the room, and the sound reaching the listeners should be free from long-delayed reflections which produce interferences or echoes.
3. The room should contain sound-absorptive materials in such amounts, and of such qualities, as will provide a proper balance between the persistence and the cessation of the articulated components of sound. In other words, the reverberation in the room should be long enough to sustain harmony and impart tonal blending to music, and at the same time it must be short enough to prevent the overlapping and the confusing of the separate sounds of articulated speech.
4. The room should be free from all sources of noise, whether of inside or outside origin.

The amount of sound energy generated by the average speaker is extraordinarily minute. In conversation a person generates on the average only 10 microwatts of speech energy. The average amount of speech energy generated by a speaker in an auditorium is somewhat greater than this, varying from about 25 microwatts in small rooms to about 100 microwatts in very large auditoriums. The acoustical power of unamplified speech is so minute that it would require all of the adult women in the United States speaking fortissimo at the same time to generate a single horse power of speech energy. It is obvious therefore that when the speech energy from a single speaker is diffused throughout a large auditorium the amount of speech energy reaching a listener in the auditorium will be almost infinitesimally small. If it were possible to set up a pressure gage in an auditorium which would be sensitive enough to measure the pressure variations in the air owing to the vibrations of sound, such as are produced by speech, the root mean square pressure variation would be less than one millionth of atmospheric pressure. But even such feeble vibrations can be recognized by the sensitive mechanism of hearing provided the acoustical conditions in the room have been made as nearly ideal as possible.

In order to gain a better notion of the loudness of speech and music and of the loudness of noise it is necessary to define a suitable unit for measuring the intensity or loudness of sound. It is becoming more and more universal to rate the intensity of sound in terms of what is called the *sensation level*. Often the term *intensity level* is used to convey the same meaning. The sensation level of a sound is defined in terms of the sound which is just barely audible to a person with nor-

mal hearing. Thus, suppose that I_1 be the average intensity of a certain sound in a room. (The intensity is rated in terms of the number of microwatts of acoustical energy fluxing through an area of one square centimeter.) Now suppose I_o be the intensity of the same sound when it has been reduced to the point that it is just barely audible by the average person with normal hearing. The *sensation level* of the sound having an intensity I_1 is then equal to

$$\text{Sensation level} = 10 \log_{10} \frac{I_1}{I_o} \qquad (1)$$

If I_1 be of such a magnitude that it is necessary to reduce its intensity one million fold in order to reduce it to the threshold of audibility, its sensation level will be equal to 60 units. This unit is called the decibel (abbreviated db). The chart shown in Fig. 1 gives the sensation levels of a number of familiar sounds, including several noises which concern the heating and ventilating engineer.

The average sensation level of speech in a small room is about 60 to 65 db, and in a large auditorium it is only 45 to 50 db, whereas the sensation level at which speech is most readily recognized is about 70 db. It is apparent therefore that the average loudness of speech in a large auditorium is at a critically low level, and consequently the acoustics of very large speech halls may be intolerably poor simply because there is an inadequate amount of speech energy for distinct hearing.

The manner in which the recognition of speech depends upon the loudness or the sensation level of speech is shown in Fig. 2[1]. The curve in Fig. 2 is based upon speech articulation tests conducted at the Bell Telephone Laboratories. Meaningless speech syllables are called out into the microphone of a distortionless speech amplifier, and observers listening with telephone receivers connected in the output of the amplifier write down what they hear. The recorded lists are then compared with the called lists. The percentage articulation represents the percentage of the called syllables which are heard correctly. The sensation level of the speech is adjusted by means of an electrical attenuator so that the sensation level of the speech can be maintained at any level between inaudibility and 90 db. It will be noted that at a level of about 45 db the articulation begins to drop off very rapidly with any further diminution of the intensity. Since 45 db is about the average level of speech in a very large auditorium it is obvious that any slight downward modulation of the speaker's voice or any slight interference from noise or

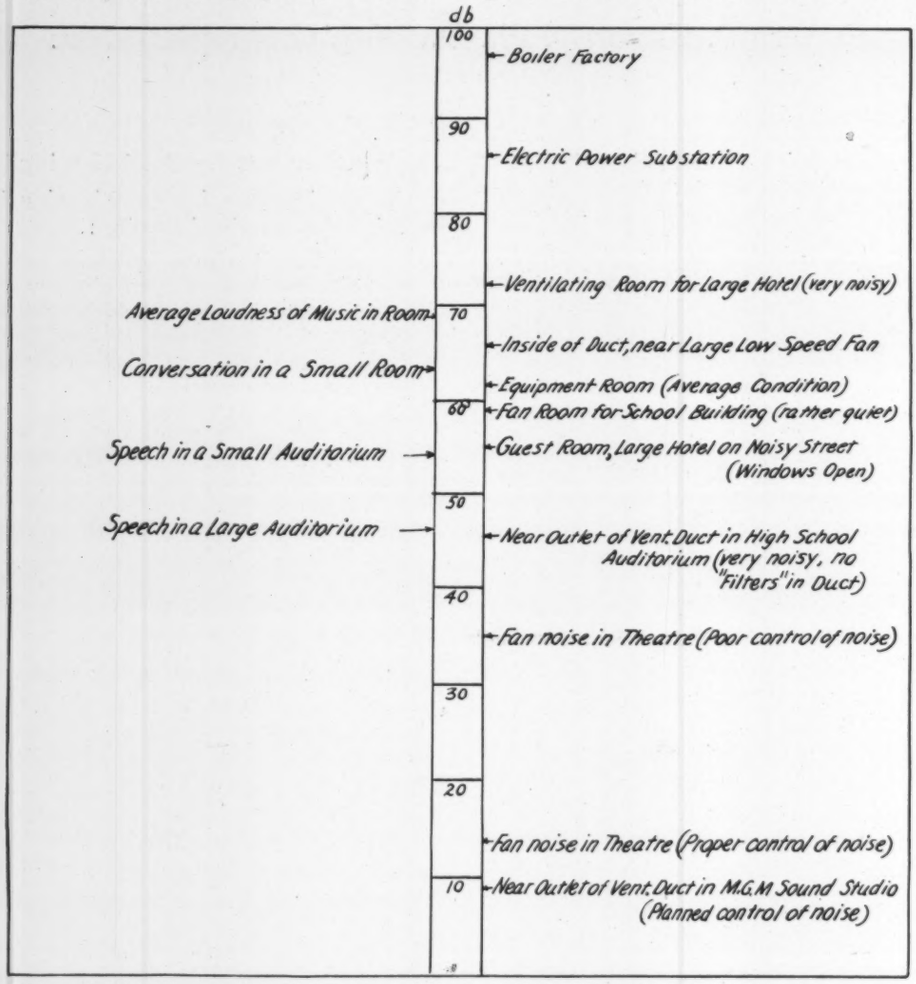
db
100
90
80
70
60
50
40
30
20
10
Boiler Factory
Electric Power Substation
Ventilating Room for Large Hotel (very noisy)
Average Loudness of Music in Room
Inside of Duct, near Large Low Speed Fan
Conversation in a Small Room
Equipment Room (Average Condition)
Fan Room for School Building (rather quiet)
Speech in a Small Auditorium
Guest Room, Large Hotel on Noisy Street (Windows Open)
Speech in a Large Auditorium
Near Outlet of Vent. Duct in High School Auditorium (very noisy, no "Filters" in Duct)
Fan noise in Theatre (Poor control of noise)
Fan noise in Theatre (Proper control of noise)
Near Outlet of Vent. Duct in M.G.M Sound Studio (Planned control of noise)

FIG. 1—CHART SHOWING THE AVERAGE LOUDNESS OF SPEECH, MUSIC, AND A NUMBER OF TYPICAL NOISES. NOTE THAT MANY NOISES INCIDENT TO THE VENTILATING OF BUILDINGS ARE CHARTED

[1] John C. Steinberg, Effects of Distortion Upon the Recognition of Speech Sounds, *Journal Acoustical Soc. of America*, 1, 121 (Oct., 1929).

any other source would interfere very seriously with the hearing of speech. The advantage gained by amplifying speech to an adequate level in large auditoriums is amply demonstrated in the modern cinema theatre. Thus, one experiences practically no difficulty in hearing reproduced speech in the modern "talkie," whereas one often experiences difficulty in hearing all of the spoken lines in the legitimate theatre. The difference is almost wholly attributable to the difference in the loudness level of the speech.

The Effect of Form Upon the Acoustics of a Room

The acoustics of every room is very much dependent upon the shape of the room. Thus, domed or cylindrical ceilings, or concave walls, are likely to give rise to sound foci, and thus the sound will be non-uniformly distributed throughout the room. Again, high ceilings or other large extensions in the dimensions of a room may give rise to delayed reflections. If a reflection be delayed as much as 55 ft behind the direct sound, the reflected sound will interfere with the direct sound, and if the delay be as much as 65 to 70 ft, the reflected sound will be heard as an echo of the direct sound. It is not within the scope of this paper to enter into a discussion of the effect of form upon the acoustics of a room, as the subject is adequately treated in any standard book on architectural acoustics.

Effect of Reverberation Upon the Hearing of Speech in a Room

Reverberation is the prolongation of sound in a room owing to the successive reflections from the boundaries of the room. Thus, in a large room bounded by highly reflective surfaces such as cement or hard plaster the reverberation of an ordinary sound may remain audible 10 to 15 seconds. It is obvious that speech would not be intelligible in such a room since the separate components of speech would overlap and confuse. If the walls of this same room be covered with a highly absorptive material, as an acoustical tile or felt, the reverberation of the same sound would be audible for only a fraction of a second. The time of reverberation in a room is defined as the time required for a sound of a certain pitch to die away to one millionth of its initial intensity. That is, if a tone in a room has an initial intensity of 60 db, then the time required for that tone to die away to inaudibility after the tone has been stopped is a measure of the time of reverberation for that tone. In general, the reverberation time of a room depends upon the pitch of a tone, and is longer for tones of low pitch than it is for tones of high pitch. The time of reverberation can be calculated by means of the formula

$$t = \frac{0.05\ V}{-S \log_e (1-\alpha)}, \qquad (2)$$

where

t represents the time of reverberation,
V represents the volume of the room in cubic feet,
S represents the total interior surface of the boundaries of the room in square feet,
α represents the average coefficient of sound-absorption of the interior boundaries of the room.

The values of α for standard building materials and other acoustical materials can be found in any standard reference book on architectural acoustics.

In Fig. 3 are given the results of speech articulation tests conducted in a number of large auditoriums, of about the same shape and size, but having different times of reverberation. The reverberation times here given are for a tone of 512 cycles per second. It is customary to regard the reverberation time of a room as the reverberation time for a tone of this pitch. Thus, the most reverberant auditorium tested in this series had a reverberation time of about 7.5 seconds, whereas the least reverberant auditorium (a modern sound stage for making talking pictures) had a reverberation time of less than one second. It will be noted that the percentage articulation improves as the reverberation time decreases. In fact, the optimal reverberation time for the hearing of speech is approximately one second. For purposes of design, the curves given in Fig. 4 are useful. They give the optimal times of reverberation for tones of different pitch in auditoriums which are to be used for both speech and music. In general, music rooms should have slightly longer, and speech rooms slightly shorter, times of reverberation than the times given by the curves in Fig. 4.

Effect of Noise Upon Hearing of Speech in an Auditorium

The acoustical problem which most concerns the heating and ventilating engineer is the effect of noise upon the acoustics of a room. Experience shows that even very feeble noises interfere with the hearing of speech, and therefore it is necessary that every precaution be taken to eliminate all possible sources of noise in auditoriums. The effect of noise upon the hearing of speech in an auditorium is shown in Fig. 5. Thus, a noise of 50 db will reduce speech articulation to approxi-

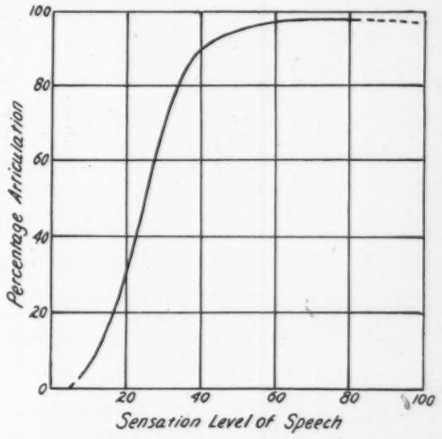

FIG. 2—THE EFFECT OF LOUDNESS ON THE HEARING OF SPEECH (AFTER STEINBERG)

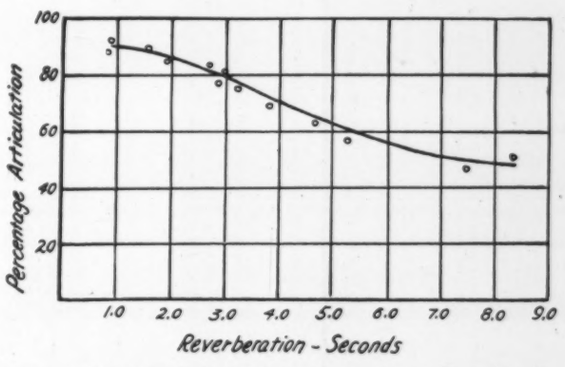

FIG. 3—THE EFFECT OF REVERBERATION UPON THE HEARING OF SPEECH IN LARGE AUDITORIUMS

mately 50 per cent, and even relatively feeble noises will produce an appreciable interference. The tests from which these data were obtained were conducted in such a manner that the speaker did not hear the noise. If the speaker as well as the listener hears the noise, the speaker will attempt to raise his voice above the level of the noise, and consequently noise in an auditorium does not produce so great an interference with the hearing of speech as is indicated by the curve in Fig. 5. If there must be some noise in an auditorium it is much better to have this noise in the proximity of the speaker than in the proximity of the listeners, since the noise will then tend to increase the loudness of the speaker's voice, and will not be so bothersome to the audience. However, noise in any form or in any part of the auditorium constitutes a serious impairment of acoustical quality, and every effort should be made to reduce noise to the utmost.

In one school auditorium concerning which the author was recently consulted, the noise from the ventilating equipment constituted the most troublesome defect in the acoustics of the room. Speech tests conducted in this auditorium showed that with the fan and motor in operation, the speech articulation was only 66 per cent, whereas with the fan and motor stopped, the articulation increased to 80 per cent. It is apparent, therefore, that the control of noise in the installation of heating and ventilating equipment is an important factor in connection with the acoustical design of an auditorium.

In every problem of noise control it is necessary to know just how much the level of the noise should be reduced. The amounts of noise which will be readily tolerated in different rooms are given in the following table:

Studios for the recording of sound, as talking picture studios	6 to 8 db
Radio broadcasting studios	8 to 10 db
Hospitals	8 to 12 db
Music studios	10 to 15 db
Apartments, hotels and homes	10 to 20 db
Theatres, churches, auditoriums, classrooms and libraries	12 to 24 db
Talking picture theatres	15 to 25 db
Private offices	20 to 30 db
Public offices, banking rooms, et cetera	25 to 40 db

The values given in this table represent what might be termed ideal conditions, and it is not often that they are realized in existing buildings. However, they represent conditions which can be attained by means of proper design and control of noise, and they represent the limits of noise which should not be exceeded by the noise from heating and ventilating equipment in different types of buildings. Thus, suppose the heating and ventilating contractor is required to guarantee that the noise reaching a theatre from his equipment will not exceed 15 db. Suppose, further, that the contractor knows that the amount of noise at the source end of the duct is, say 60 db. It will then be necessary to introduce acoustical attenuation between the source end of the duct and the auditorium in the amount of 60—15, or 45 db. His problem then becomes an engineering one which is amenable to calculation. Practical methods of meeting this type of problem will be considered in the following section.

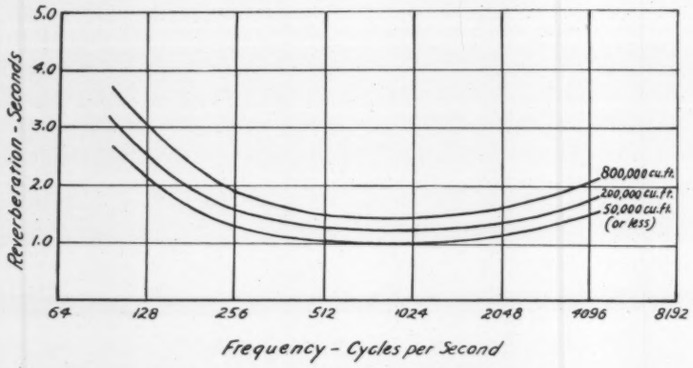

FIG. 4—OPTIMAL REVERBERATION CHARACTERISTICS FOR ROOMS USED FOR BOTH SPEECH AND MUSIC

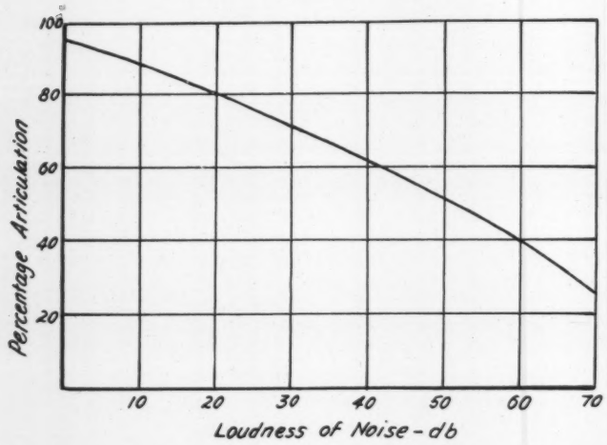

FIG. 5—CURVE SHOWING THE EFFECT OF NOISE ON THE HEARING OF SPEECH

Measuring Noise in Ventilating Equipment

For most practical problems in connection with noise measurement and the insulation of noise, it is sufficient to specify the sensation level of the noise for low, medium and high pitched sounds; for example, for frequencies of 128, 512 and 2048 cycles per second. It is convenient, however, and attempts are often made, to evaluate the loudness of the noise in terms of a single number, as for example by specifying the sensation level of a pure tune of 1000 cycles per second which is judged to be of the same loudness as the noise. Such evaluations, although useful, do not describe the character of the noise, and if used at all in problems of noise insulation they should be used only with a knowledge of how the noise is distributed throughout the frequency range. Fortunately, most noises have their maximal sensation level within the octave between 512 and 1024 cycles per second, so that if the sensation level of the noise be determined in this range one will have a measure of the noise which is sufficiently accurate for most engineering purposes.

Several practical methods have been developed for the measurement of noise.[2] At a recent symposium on noise measurement conducted by the *American Institute of Electrical Engineers* in April, 1931, eight different instruments for the measurement of noise were presented. Three of these methods will be considered briefly in this section: (1) the tuning fork method, (2) the audiometric method, and (3) the acoustimeter method. The tuning fork method, described by Davis[3], is extremely simple, but gives quite satisfactory results if used with proper care. Davis used a single fork having a frequency of 640 cycles, but the same type of measurements can be made with several forks. In general, it is advisable to use at least three forks—tuned to say 128, 512 and 2048 cycles. The 2048 fork, at least, should be of the Duratone type, which has a very low damping and therefore dies away much more slowly than does a steel fork. Steel forks are quite satisfactory at 128 and 512 cycles. First of all, the forks must be calibrated. It is necessary to know the intensity, in db, of each fork immediately after it has received a standard blow or excitation. If the fork be allowed to fall from a vertical position through an arc of 90 deg, hitting a suitable pad (such as soft rubber or felt for the low pitched forks and hard rubber for the high pitched forks), with a little practice the initial intensity can be reproduced to an accuracy of 1 or 2 db. It is then necessary to know the rate of decay of the forks. In general, the rate of decay in sensation units will be a constant number of decibels per second. The rate of decay can be determined very readily in any well-equipped acoustical laboratory. The 512 steel fork will have an initial intensity of about 70 or 80 db, and it will decay at a rate of about 1.2 to 1.7 db per second. Lower pitched forks decay more slowly and higher pitched forks decay more rapidly than does the 512 fork. In a perfectly quiet room steel forks may remain audible, when held close to the ear with the broad side of the prong toward the opening of the ear canal, from about 50 to 70 seconds, and Duratone forks will remain audible a hundred seconds or longer. If the rate of decay in db per second and the duration of audibility in a *quiet* room have been determined for a fork, its initial intensity will be equal to the rate of decay times the duration of audibility. Thus, if the rate of decay for a fork is found to be 1.1 db per second, and the duration of audibility after it has been given a standard hit is 60 seconds, the initial sensation level of the fork will be 66 db above the threshold of the individual making the measurements. The hearing acuity of this individual should then be compared with the normal (by means of a calibrated audiometer) and an appropriate correction applied to the initial intensity level of the fork.

[2] E. E. Free, Practical Methods of Noise Measurement, *Journal Acoustical Soc. of America*, 2, 18 (1930). R. H. Galt, Results of Noise Surveys—Noise Out of Doors, *Journal Acoustical Soc. of America*, 2, 30 (1930). R. S. Tucker, Noise in Buildings, *Journal Acoustical Soc. of America*, 2, 59 (1930). J. S. Parkinson, Vehicle Noise and Noise Reduction, *Journal Acoustical Soc. of America*, 2, 65 (July 1930).

[3] A. H. Davis, Measurement of Noise by Means of a Tuning Fork, *Nature*, 125, 48 (Jan 11, 1930).

How to Measure Noise

The method of measuring any noise is as follows: The observer, in the presence of the noise, strikes the fork a standard blow and at the same instant starts a stop watch. The fork is then held in front of the ear canal, moving it back and forth slightly, until the tone of the fork is just completely masked by the noise, at which instant the watch is stopped. This measurement is then repeated two or three times and the average of all readings will make it possible to calculate the sensation level of the noise at that particular frequency.

Thus, suppose that the fork has an initial intensity of 66 db, and that its tone decays at a rate of 1.1 db per second. Then if the fork remains audible only 20 seconds in the presence of the noise, it means that the masking effect of the noise at this frequency is 66—22, or 44 db. Similar readings are obtained at other frequencies, and the resulting data will give an approximate audiogram of the measured noise. Measurements of this type, made with 128, 512 and 2048 forks, give a very satisfactory description of the intensity and frequency distribution of different types of noise. Both the apparatus and the method of measurement are extremely simple and are fairly reliable.

A somewhat similar and also a very convenient method for making an approximate measurement of noise is made possible by means of a buzzer type of audiometer, such as the Western Electric 3A Audiometer. The buzzer in this audiometer has a fundamental frequency of 160 cycles, and it has an abundant supply of overtones, so that its noise is quite representative of most noises produced by heating and ventilating equipment. The receiver of the audiometer is equipped with an off-set receiver cap so that the ear of the observer hears both the noise of the audiometer and the noise which is to be measured. The observer first determines the amount of attenuation (in db) which must be introduced in the audiometer to reduce the buzzer sound to inaudibility when listening in a perfectly quiet place. He then makes a similar measurement when listening in the presence of the noise which is to be measured. The difference in the two readings of the audiometer, in the quiet place and in the noise, then gives a rough measure of the masking effect of the noise. The masking effect of the noise, as measured by the threshold shift on the audiometer dial, will usually be about 5 to 10 db less than the sensation level of the noise.

In the acoustimeter method of measuring noise, the noise vibrations are picked up by a microphone, amplified by a vacuum tube amplifier, passed through a frequency weighting network, and registered or recorded

by a suitable galvanometer. The frequency weighting network is based upon the sensitivity and sensibility characteristics of the normal human ear, so that the deflections registered by the instrument will be comparable to those which would be heard by the ear. A single reading of the instrument will therefore give a fairly reliable measure of the "noisiness" of the noise, although the effect of the frequency weighting network will introduce certain errors owing to variations of intensity and frequency distribution in different noises. Such an instrument is especially useful for obtaining a continuous record over an extended period of time.

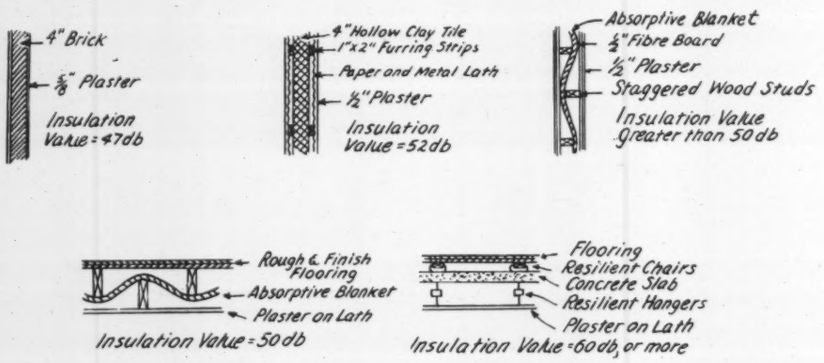

FIG. 6—THREE WALL SECTIONS AND TWO FLOOR AND CEILING SECTIONS WHICH WILL PROVIDE A SOUND-INSULATION OF MORE THAN 45 db.

Practical Methods of Reducing Noise in Heating and Ventilating Equipment

In a recent paper the author discussed practical methods of controlling noise in heating and ventilating equipment.[4] The specific noise problems which confront the heating and ventilating engineer are the following:

1. Improvements in the quiet operation of equipment.
2. The location and insulation of the equipment room so that no noises are transmitted through the walls, the ceiling, or through openings, into rooms where quiet is required.
3. The isolation of all vibrating or rotating equipment, so that the vibrations will not be communicated to the solid frame of the building.
4. The prevention of noise transmission through the ventilating ducts.

In order to illustrate the manner in which the noise incident to a typical installation of air conditioning equipment can be controlled, suppose that it is required to provide a quietly operating system of ventilation for a theatre. Preferably, the equipment room should be located at a considerable distance from the theatre auditorium, but this is not necessary if proper steps be taken to insulate the noise which may be transmitted through the walls of the equipment room and also the noise which may be transmitted through the ducts. All rotating or vibrating equipment should be mounted on flexible supports which are so resilient that the natural frequency of the mass of the equipment on the flexible support will be low in comparison with the frequencies of the vibrations generated by the equipment. If the fundamental frequency of vibration produced by the machine be 100 cycles per second, the natural frequency of the mass of the machine on its flexible support should not be greater than about 20 cycles per second. Since the noise level in the theatre should not exceed 15 db, it is necessary to supply sufficient insulation to reduce the noise to this level. Suppose that measurements have been made of the noise generated by the ventilating equipment in a typical equipment room and that these measurements reveal a noise level of 60 db in the equipment room and a noise level of 65 db in the duct at its input end. If the equipment room is adjacent to the theatre auditorium it will then be necessary to design the walls and ceilings of the room in such a manner as will provide an effective insulation of at least 45 db between the equipment room and the auditorium. In Fig. 6 are shown three types of wall sections and two types of floor and ceiling sections which will supply an insulation in excess of 45 db. With properly designed walls and ceiling, such as those shown in the figure, the equipment room can be located as near the auditorium as is desired, provided further that sufficient insulation be introduced in the ducts. The sound attenuation (or reduction) which must be introduced in the ducts between the fan and the theatre auditorium is 65—15, or 50 db. In order to provide the required amount of attenuation, it is necessary to know the attenuation per foot of ducts of different cross sectional areas and of different materials for the duct walls. In general, and to a first approximation, the reduction (in db) of noise transmitted through ducts is proportional to the length of the duct, inversely proportional to the "size" (lineal dimensions, as the average of the width and the height) of the duct, and proportional to the coefficient of sound-absorption of the interior surfaces of the duct. Long, narrow ducts, lined with highly absorptive material, provide very effective *attenuators* or *sound filters*. A small duct, having a cross section of about 4 in. by 6 in., lined with a highly absorptive felt or fibre board, will provide an insulation of at least 1 db per foot. Quantitative information is needed concerning the amounts of attenuation or noise reduction provided by different types and sizes of ducts. Manufacturers of ventilating equipment should obtain data of this sort, as these data would make it possible for engineers to provide a specified amount of noise reduction in any duct system, and thus in every installation it would be possible to design in advance of the construction the type and length of ducts required to effect a proper reduction of the noise. Already some of the leading makers of air conditioning equipment have procured the necessary data for coping with the problem, and are routinely installing in the ducts *noise filters* which are designed to meet the noise requirements for each installation. Some useful data and suggestions will be found in a recent paper by Larson and Norris.[5]

[4] V. O. Knudsen, How Sound Is Controlled, *Heating, Piping and Air Conditioning*, 3, 10, 815-820 (Oct., 1931).

[5] G. L. Larson and R. F. Norris, Some Studies on the Absorption of Noise in Ventilating Ducts, *Heating, Piping and Air Conditioning* (Jan., 1931).

Some Fundamental Considerations of Corrosion in Steam and Condensate Lines

By R. E. Hall[1], Pittsburgh, Pa., and A. R. Mumford,[2] New York, N. Y.
NON-MEMBERS

The first section of this paper appeared in the November, 1931 *issue. In this second and concluding section is presented a detailed discussion of the data collected in the utilizing system in addition to a summary and conclusion of the entire paper.*

THE utilizing system comprises those parts of the system (1) in which steam flow and steam pressure are subject to intermittency, and (2) in which the water, derived from condensation of the steam, passes to waste or is returned to the generating system. Intermittently, therefore, in (1) and continuously in (2) equalization of internal pressure with that of the surrounding atmosphere may be attained by leakage into the conduits of the atmospheric gases. The partial pressure in the system of the extraneous atmospheric gases may vary between the limits of very small value originating from the steam itself to very large values occasioned by excessive inleakage of air into the system. In this, as well as in the preceding division of the system, the rate of solvent action of the condensate is a maximum because of its purity and elevated temperature.

On the other hand, so long as the condensate is uncontaminated by dissolved gases, or has available only very limited quantities thereof, the capacity factor of its dissolving power is very small. It has been demonstrated that the capacity factor reaches unlimited proportions when, by inleakage, ample supply of dissolved oxygen is maintained in the condensate by either continuous or intermittent presence of any considerable partial pressure thereof in the vapor in contact with the condensate. Hence, in this third division, the capacity factor usually flowers into greatest prominence because it is supported by leakage of air into the system. Responsibility of the generating system in this division is limited to those effects attributable to the nature and quantity of components in the steam as delivered to the utilizing system; the latter must accept full responsibility for effects incurred by reason of change in the nature or quantity of those components.

Problems of Utilization Division

In this division, characterized by intermittency of steam flow and pressure, and by inleakage of atmospheric gases, the origin of any deposits that are found can be adjudged with certainty when their chemical composition is known. If the origin is carry-over from the boiler, the deposit reflects the characteristics of the boiler-water sludge; if the origin is corrosion, the deposit is characteristically iron oxide, since iron is usually the only material available for corrosion, and in all cases is the material most susceptible to corrosion.

Analyses for Oxygen and Carbon Dioxide at Various Points in Building A and Building B

In the specific system under consideration, the data of Tables 5 and 11 have led to adoption of the figure 0.5 ml/liter as a generous estimate of the average amount of oxygen in the steam. Even if the average concentration had been 1.0 ml/liter the considerations set forth in the discussion of Division 2 show that condensate, not reinforced by oxygen from the atmosphere, would contain so little dissolved oxygen that its aid as the quantity factor in corrosion would be well-nigh negligible.

Both in Building *A* and in Building *B*, the data on oxygen presented in Table 11 show that excess thereof over and above that accounted for by the steam itself is present in considerable quantity at different points. The latter building shows a worse condition than the former, the analysis of the returns being particularly indicative of much inleakage of air. In the data on Building *A*, considerable oxygen is found in the steam before the trap on the return from the 29th floor hot-water tank (Section 1, line 5), although the steam in the 5-lb header (line 6) contains only 0.42 ml/liter of oxygen. The *condensate* at the outlet of the trap contains 1.10 ml/liter. These data were discussed in the preceding sections of this report, and the conclusion was reached that in no conceivable way can the amount of oxygen in the condensate be derived from the oxygen in the steam. Table 11, Section 1, No. 8, shows that the returns before the vacuum pump contain 4.48 ml/liter of oxygen, and as the temperature of these returns lies within the limits of 140 — 170 F, this value is actually more than saturation for water at this temperature in contact with air, and blanketed with its own vapor. (See Table 1).

In the samples taken at Building *B*, greater prevalence of high oxygen is found than in those taken at Building *A*. Some of this may of course come from condensation of steam with concomitant concentration of the non-condensable gases, as in the hot-water heaters, mangles and kitchen, but the concentration of oxygen so derived,

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[2] Research and Design Engineer, New York Steam Corporation.
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as indicated for instance in Nos. 5, 6, 7 and 8 (Table 11, Section 2), can account for but slight dissolved oxygen in any condensate, in accordance with the conclusions arrived at in connection with Table 10. In No. 10 of Table 11, Section 2, is found definite evidence of the influx of air accompanying operation of the vacuum pump. The *pH* values of these samples are of interest—higher than those others noted in condensate further along in the utilizing system, and thus denoting the removal by this drip of the extremely small content of boiler water carried by the steam. The fact that no carbon dioxide is found in these samples is confirmatory of the view, previously expressed in part, that the absolute values of small quantities of carbon dioxide are very likely more a matter of indicators and end-points, than any reality. No analysis of the return water before the vacuum pump is available, but as the temperature thereof is 140 to 170 F as in Building *A*, the value is doubtless comparable to the 4.48 ml/liter found for Building *A*.

The composition of the vapor discharged by the vacuum pump has been determined by Markson in a typical case to be 0.7 per cent and 16.1 per cent by volume of carbon dioxide and oxygen respectively. More recent and extensive data, accumulated during the investigation of Building *A*, are presented in Table 12. These analyses show that the vented gas is largely air. Thus, in steam containing 0.5 ml/liter of oxygen and 19.6 ppm. of carbon dioxide, the ratio by weight of oxygen to carbon dioxide is 1:27.5; and in the air as analyzed in the basement was 148:1. In the vapors vented from the system the ratios are respectively; 38:1, 48:1, 144:1, and 147:1. Because of the similarity of these ratios in vented vapors to that in air, and because of their total dissimilarity to the same ratio in the steam, it is obvious that the oxygen and carbon dioxide brought to the system by the steam constitute a wholly negligible fraction of the vapors in the system. A simple calculation, based on steam containing 0.5 ml/liter of oxygen and 19.6 ppm. of carbon dioxide, emphasizes this conclusion. The total carbon dioxide, oxygen and nitrogen in such steam amount to 226 cu ft at 170 F for each million pounds of steam. In Building *A*, the total heating surface in use (direct and indirect) is 120,272 sq ft. If condensation amounts to ¼ lb per square foot per hour, the steam requirement of the building is 30,068 lb per hour. Thus, if the vacuum pump removed all the gases supplied by the steam, it would vent only 6.8 cu ft per hour. This figure is a maximum, and negligible in comparison to the actual venting from the system as shown in the 6th column of Table 12, when the actual steam flow to the building was only 11,000 to 16,000 lb per hour.

Analyses of Deposits, Building A and Building B

In Table 13, Section 1, are given analyses of deposits from the Building *A;* in Table 13, 1-a, are found descriptions of the deposits, and rough estimates of their quantity.

In viewing the table as a whole, the most impressive characteristic is that of line 11—*Magnetic*—defining with all certainty the origin of these deposits as of corrosive action. The quantity of iron oxide present expressed as ferric oxide (line 5) further shows that with two exceptions, Nos. 1 and 3, this substance dominates these deposits in large measure. From line 3 it is seen that the phosphate content—the contribution to these deposits of carry-over in the steam—is, in the main, practically negligible. Exceptions are Nos. 1, 1-a, 8 and 17.

The difference between Nos. 1 and 1-a is probably due to variations in operating practice at different seasons of the year. Thus No. 1 was taken in the winter, when the rating on the boilers in the generating system and hence the carryover therefrom was maximum. No. 1-a was taken in the summer, when rating and carryover are a minimum, and when, therefore, without any increase in rate of corrosion any material of corrosive origin would constitute a greater part of the sample. The elimination by the generating system of moisture from the steam is now so nearly complete, that all samples of deposits from the 90-lb headers will doubtless conform more nearly to 1-a than to 1.

The high silica in No. 3 is the cause for the lower value of iron oxide. The fact that this trap had never been cleaned since the installation of the system probably accounts for this value. This accounts likewise for the high silica of Nos. 2, 4, 8 and 15.

The high phosphate of Nos. 1 and 1-A indicate that as carryover occurs, much of the phosphate material is eliminated at the 90-lb header. That of Nos. 8 and 17 probably dates back considerably, as these traps had never been cleaned, and the quantity of carryover from the generating station has been progressively growing less. No explanation is apparent why phosphate should be low in No. 2, which is a sample from a trap on the high pressure line that had never been cleaned, especially in view of the evidence afforded by the high *pH* values of condensate (Table 11, Section 2, No. 10), that removal of any carryover of boiler water occurs in this part of the system.

The further measure of the separator installed just prior to the distributing mains represents an additional effective barrier against any quantity of deposit arriving at the 90-lb header, and thus will eliminate or minimize any troubles caused thereby, either at the main reducing valve located at this point, or at those other points noted as characterized by high phosphate in this series of tests. Under these conditions, it seems likely that the separator installed in Building *A* will have little or no work to do, thus rendering its installation unnecessary.

In Table 13, Section 2, are presented results on various samples taken from Building *B*. Complete analyses were not made, but the descriptions *Magnetic, trace of phosphate* or *no phosphate* and *oxides of iron* show that these deposits belong in the category of corrosion products, just as truly as those from Building *A* which have just been discussed.

The corrosion which these buildings have experienced requires real quantities of oxygen. The corrosive possibilities of the present steam with its 0.5 ml/liter of oxygen are practically negligible. No relief from the deposits so excessively high in iron can be expected to result from any further measures the generating system may take either to eliminate carryover or to reduce the oxygen concentrations in the steam. All considerations that have been discussed point to minimal effects from considerably higher oxygen concentration in the steam than have existed heretofore, in comparison with the effects induced by the hundred fold times this amount

TABLE 12—OXYGEN AND CARBON DIOXIDE IN GASES VENTED FROM THE HEATING SYSTEM OF BUILDING *A*

Tests made 4/23/31—Analyses by Orsat

TEST No.	TIME	STEAM FLOW (LB PER HOUR)	HIGH PRESSURE HEADER (LB PER SQ IN. GAGE)	AIR TEMP. (DEG FAHR)	CU FT PER MIN. THROUGH VENTS	VACUUM IN TANK INCHES MERCURY	GASES PER CENT BY VOLUME	
							O_2	CO_2
1	7-8:07 A. M.....	12,400	70	82	34.7	3.5*	21.0	0.4
2	11-12 Noon.....	11,000	76	114	1.18	0	20.0	0.3
3	3-3:30 P. M.....	15,300	69	110	3.22	0	20.2	0.1
4	3:30-4:00 P. M.....	16,100	65	66	1.54	4.5	20.6	0.1
5	Air analysis in basement, 4/24/31.....						20.7	0.1

*Vacuum pump running at start of test. Pump stopped at 8:00 A. M.

TABLE 13—DEPOSITS TAKEN FROM VARIOUS SOURCES—BUILDING *A*

Analyses in Per Cent

SECTION 1

	1	1A	2	3	4	5	6
	TRAPS ON 90-LB HEADER	TRAPS ON 90-LB HEADER	TRAP AT HIGH PRESSURE 60-LB LINE, 16TH FL. WATER HEATER	LOW PRESSURE DRIP TRAP INLET OF WATER HEATERS 16TH FL.	TRAP AT OUTLET FROM WATER HEATER 16TH FL.	PRIMARY REDUCING VALVE 19TH FL.	12-IN. REDUCING VALVE 19TH FL.
1. Sulphur Trioxide (SO_3)	1.4	2.5	1.3	1.4	1.7	4.0	Not enough sample
2. Carbon Dioxide (CO_2)	Included in Ignition Loss.						
3. Phosphorous Pentoxide (P_2O_5)	16.6	9.8	1.3	2.0	1.7	2.5	2.0
4. Silica (SiO_2)	22.3	5.9	19.0	36.5	12.7	3.7	3.6
5. Ferric Oxide (Fe_2O_3)	28.7	80.1	76.7	41.6	70.7	76.7	64.1
6. Aluminum Oxide (Al_2O_3)		4.8	6.8	10.5	9.7	9.6	Not enough sample
7. Calcium Oxide (CaO)	15.0	8.1	0.7	6.0	6.0	2.6	8.8
8. Magnesium Oxide (MgO)	11.9	1.1	1.1	1.7	0.7	0.7	5.4
9. Loss at 105 C	0.5	0.1	0.4	0.4	0.4	1.0	2.7
10. Ignition Loss	3.0	0.2	0.1	2.3	4.9	8.7	10.6
11.	slightly magnetic	magnetic	magnetic	magnetic	magnetic	magnetic	magnetic

TABLE 13—DEPOSITS TAKEN FROM VARIOUS SOURCES—BUILDING *A*

Analyses in Per Cent

SECTION 1 (Cont'd.)

	7	8	9	10	11	12	13	14
	DRIP TRAP INLET TO WATER HEATER 29TH FL. (LOW PRESSURE)	TRAPS ON 53RD FL.	PIPE OF RETURN LINE OF PRESSURE GAGE SYSTEM	DIRT POCKETS PRESSURE GAGE SYSTEM HOUSE HEATING SYSTEM	DIRT POCKET PRESSURE GAGE SYSTEM 26TH FL. WATER HEATER	DIRT POCKET PRESSURE GAGE SYSTEM 29TH FL. WATER HEATER	DRIP OF PRESSURE GAGE SYSTEM TRAP 29TH FL. HOT WATER SYSTEM HEATER	DRIP ON PRESSURE GAGE SYSTEM 16TH FL. WATER HEATER
1. Sulphur Trioxide (SO_3)	2.9	1.4	1.2	2.6	2.6	2.3	0.8	1.7
2. Carbon Dioxide (CO_2)	Included in Ignition Loss.							
3. Phosphorous Pentoxide (P_2O_5)	2.3	12.0	2.1	1.0	1.7	1.8	0.5	0.6
4. Silica (SiO_2)	4.8	13.8	0.8	2.6	4.2	3.2	0.9	1.1
5. Ferric Oxide (Fe_2O_3)	93.0	61.1	86.4	61.1	80.1	81.8	92.4	88.3
6. Aluminum Oxide (Al_2O_3)	5.7	4.7	5.8	15.2	8.7	4.8	3.5	1.8
7. Calcium Oxide (CaO)	3.7	12.0	1.0	5.6	0.5	3.5	1.7	2.7
8. Magnesium Oxide (MgO)	0.9	0.5	0.8	2.3	1.5	1.5	0.1	1.0
9. Loss at 105 C	0.3	1.2	0.2	1.4	0.2	0.4	0.8	2.2
10. Ignition Loss	2.0	2.9	7.7	11.1	7.7	8.2	1.9	6.2
11.	magnetic	magnetic	magnetic	magnetic	magnetic	magnetic	magnetic	magnetic

of oxygen that intrudes itself into the system by sundry paths.

It is the opinion of the authors that these deposits are products of corrosion caused by the large quantities of inleakage oxygen, and that their elimination or satisfactory limitation will require elimination of such inleakage or/and establishment of these conditions in the system which will minimize the corrosive action of any oxygen which does not get into the system.

Analyses 21 and 22 of Table 13, Section 1, are of particular interest. In this case, practically identical corrosion products, formed in identical loci on different radiators, are found, one on a steel and one on a brass nipple. In each case, they filled the ½ in. nipple, save for an opening of about ⅛-in. diameter at the center. The surfaces of the deposits were marked by convolutions as though the condensate, discharged from the radiator through trap, passed through the nipples with a swirling motion.

The two deposits were different in one respect. In the steel nipple the deposit close to the metal surface was strongly magnetic; closer to the surface of the deposit and nearer the center of the nipple it was only slightly magnetic. The entirety of the deposit on the brass nipple was only slightly magnetic.

The body of the trap between nipple and radiator is

TABLE 13—DEPOSITS TAKEN FROM VARIOUS SOURCES—BUILDING *A*

Analyses in Per Cent

SECTION 1 (Cont'd.)

	15	16	17	18	19	20	21	22
	HIGH PRESSURE TRAP 19TH FL.	HEEL OF 8-IN. RISER 90-LB LINE	INSIDE OF BODY OF 12-IN. REDUCING VALVE 19TH FL.	UPTOWN CLUB KITCHEN 26TH FL. COFFEE URN RETURNS	HIGH PRESSURE TRAP 53RD FL.	THERMOSTAT TRAP LOW PRESSURE HEADER, 19TH FL.	DEPOSIT ON STEEL NIPPLE FOLLOWING RADIATOR	DEPOSIT ON BRASS NIPPLE FOLLOWING RADIATOR
1. Sulphur Trioxide (SO_3)	0.6	nil	.....	.....	.....	.....	nil	nil
2. Carbon Dioxide (CO_2)	.....	.....	.....	.....	.....	.....	.....	.....
3. Phosphorous Pentoxide (P_2O_5)	1.4	2.1	19.8	5.4	1.0	1.3	trace	trace
4. Silica (SiO_2)	15.5	7.1	.....	.....	.....	.....	0.7	0.3
5. Ferric Oxide (Fe_2O_3)	78.7	95.2	.....	.....	97.3	.....	91.1	92.0
6. Aluminum Oxide (Al_2O_3)	3.0	.....	.....	.....	.....	.....	.....	.....
7. Calcium Oxide (CaO)	2.9	trace	.....	.....	.....	.....	nil	nil
8. Magnesium Oxide (MgO)	1.2	trace	.....	.....	.....	.....	nil	nil
9. Loss at 105 C	1.5	.....	.....	.....	.....	.....	.....	.....
10. Ignition Loss	1.3	.....	.....	.....	.....	.....	8.8	7.9
11.	magnetic	magnetic	slightly magnetic	magnetic	magnetic	magnetic	magnetic	slightly magnetic

DESCRIPTION OF SAMPLES OF TABLE 13

1. *Trap on 90 lb Header.* (Sample taken in spring.) No record of quantity present.

1A. *Traps on 90 lb Header.* (Sample taken in summer.) 1 in. bucket trap, light deposit in East trap, fairly heavy in West. Deposit caked. Magnetic, dark gray powder, part was soft, partly gritty. East trap cleaned in June, West in April. Amount: East, 1—2 gms. (cleaned 1 mo. previous.) West, 50 gms. (cleaned 3 mo. previous).

2. *Trap at High Pressure, 60 lb Line, 16th Floor, Water Heater.* Bucket trap. Small amount of deposit loose in trap. Magnetic, sandy mixture of white, black and brown particles. Trap had never been cleaned. Amount, 30-35 gms.

3. *Low Pressure Drip Trap, Inlet of Water Heater, 16th Floor.* Ball trap. Deposit fairly loose, about 1/64 inch thick. Magnetic, brownish powder, mostly soft with sandy particles. Trap had never been cleaned. Amount, 30-40 gms.

4. *Trap at Outlet from Water Heater, 16th Floor.* Ball trap. Deposit about 1/64 in. thick, caked. Magnetic, brown, soft powder. Trap had never been cleaned. Amount, 30-40 gms.

5. *Primary Reducing Valve, 19th Floor.* Deposit about 1/32-1/16 in. thick. Magnetic, orange-brown, soft powder. Cleaned in February. Amount, 5-10 gms.

6. *12-Inch Reducing Valve, 19th Floor.* Deposit was paper thin. Some pitting on cast iron housing and upper cap of valve body. Magnetic, brown, soft powder. Cleaned in March. Amount, 15-20 gms.

7. *Drip Trap Inlet to Water Heater, 29th Floor.* (Low Pressure.) Ball trap. Deposit same in appearance and quantity as that on 16th floor. Magnetic, black, soft powder. Never cleaned.

8. *Traps on 53rd Floor.* Ball trap. Deposit was soft. Magnetic, brownish, gray, soft powder. Never cleaned. Amount, over 100 gms.

9. *Pipe of Return Line of Pressure Gage System.* One inch pipe practically closed with brown deposit. Magnetic, reddish-brown, soft powder.

10. *Dirt Pockets Pressure Gage System House Heating System.* Magnetic, brown and orange-brown particles, soft, easily powdered. Cleaned in spring. Amount, 10 gms.

11. *Dirt Pocket Pressure Gage System, 26th Floor Water Heater.* Magnetic, dark brown, scaly, soft powder. Cleaned in May 2 mos. previous to this examination. Amount, 5 gms.

12. *Dirt Pocket Pressure Gage System, 29th Floor Water Heater.* Magnetic, scaly, dark brown powder. Cleaned in May 2 mos. previous to this examination. Amount, 5-10 gms.

13. *Drip of Pressure Gage System, Trap, 29th Floor, Hot Water System Heater.* Magnetic, reddish-brown, soft powder. Amount, 10 gms.

14. *Drip of Pressure Gage System, 16th Floor Water Heater.* Magnetic, brown, soft powder. Amount, 3-5 gms.

15. *High Pressure Trap, 19th Floor.* Bucket trap, deposit about 1/64 in. thick, caked. Black, magnetic, soft powder, gritty. This trap never cleaned. Amount, 10-15 gm.

16. *Heel of 8-in. Riser, 90 lb Line.* Magnetic, dark gray to black, gritty grains, caked.

17. *Inside of Body of 12-in. Reducing Valve, 19th Floor.* Slightly magnetic, light color.

18. *Uptown Club Kitchen, 26th Floor, Coffee Urn Returns.* Black, magnetic, soft powder.

19. *High Pressure Trap, 53rd Floor.* Brown, soft, magnetic powder, suspended in water.

20. *Thermostat Trap Low Pressure Header. 19th Floor.* Magnetic, reddish-brown, flaky.
Samples 16-20 were too small for complete analysis.

21. *Deposit on Steel Nipple Following Radiator.* Brown deposit, readily pulverized. Magnetic.

22. *Deposit on Brass Nipple Following Radiator.* Brown deposit, readily pulverized. Magnetic.

TABLE 13—DEPOSITS TAKEN FROM VARIOUS SOURCES —BUILDING *B*

SECTION 2

SPECIMEN MARKED	DESCRIPTION OF SAMPLE	ANALYSIS
Cafeteria inlet to trap	Reddish-brown, adherent, magnetic.	Oxides of iron, especially Fe_3O_4; no phosphate.
Grill-steam table Exp. trap outlet.	Dark brown, adherent, magnetic.	Oxides of iron. No phosphate.
Cafeteria-steam table trap outlet.	Dark brown with light brown spots. Adherent, magnetic.	Oxides of iron. No phosphate.
Cafeteria and Grill-room common return.	Dark gray to black. Adherent, magnetic.	Oxides of iron. Trace phosphate.
Grill-room steam table. Exp. trap inlet.	Black to yellowish-brown. Flaky, easily chipped, magnetic.	Oxides of iron. Trace phosphate.
Laundry. Common return from Eagle press.	Reddish-brown, adherent, magnetic.	Oxides of iron. No phosphate.
Laundry. Am. Eagle Press exp. trap inlet.	Reddish-brown, adherent, magnetic.	Oxides of iron. No phosphate.
Laundry. Am. Eagle Press. Exp. trap outlet.	Reddish-brown, adherent, magnetic.	Oxides of iron. Trace phosphate.
Hot water tank return. Trap outlet nipple.	Dark brown, adherent, magnetic.	Oxides of iron. Trace phosphate.
Hot water tank. Trap inlet nipple.	Dark brown, adherent, magnetic.	Oxides of iron. Very faint trace of phosphate.

apparently of corrosion-resistant steel; the thermostatic element of ordinary steel, copper plated. Corrosion deposit covers both, though to no degree of thickness commensurate with that of the nipples.

One definite conclusion may be reached, namely, that the dissolution of metal occurs at other surfaces than those on which deposition eventuates. This must be so, else the deposit would not be found on the brass nipples.

Where does the dissolution of metal occur? What is the mechanism of formation of the deposit in the nipples?

Before attempt is made to answer these questions, it will be well to consider the data presented in Table 14, which show that the rapid development of these deposits in the period of a few months is specific to Building *A*. Thus, whereas in Building *A* the deposit builds quickly on the nipples and elbow (Nos. 1 — 3) following the radiator discharge trap to 0.00075 — 0.0018 lb per square inch of surface exposed, in Building *E* (No. 4), it reaches only 0.00046 lb per square inch in seven years. Furthermore, in the latter case, the deposit is very hard and dense, and restricts but very slightly the diameter of the tube. Because of the little nodules apparent over the surface, which are black beneath the surface covering, and because of its extremely tight adherence to the metal, it is the authors' belief that the latter deposit represents formation *in situ*, and once definitely established, forms a fairly impermeable coating which resists further attack. The deposit in the nipples from Building *A* is soft, devoid of nodules, and much more loosely attached, indicative of the special conditions surrounding its accumulation. To answer the above questions, these special conditions must be recognized. When the radiator is functioning as a heating unit, its surfaces are wetted by water in contact with a gaseous phase of very low partial pressure of oxygen and carbon dioxide. Hence both the capacity and the rate factor for dissolution of the metal are small. After the steam in the radiator system has been turned off, the temperature drops quickly as shown by the curves of Fig. 2. Condensation should occur as quickly, and before the partial pressure of oxygen has increased to sizable value because of inleakage of air, the surfaces of the radiators should have drained thoroughly, and without leaving casual droplets of water adhering thereto. This last must be the case, since one of the best tools of the chemist for obtaining clean surfaces which drain uniformly is to subject them to steam condensation for a few hours, whereby all grease films are removed. Such drainage doubtless quickly results in dryness of the radiator surfaces, and hence immunity from the quantity dissolution that would ensue with certainty, were they wet when the partial pressure of oxygen became high.

In Building *A*, however, all heating returns from the various heating levels feed into a common vacuum pump inlet header. The hot water tank returns feed into the heating return lines connected to the system from the 32nd to 55th floor. The 19th floor low pressure heating header discharges into the intermediate and low heating system returns, i.e., below the 32nd floor, by thermostatic drip traps. These thermostatic traps are opened when the system is cooling, since a vacuum is created on the inlet side by reason of condensation of the steam in the low pressure header and in the heating system. Air can enter the hot water trap returns by vacuum breakers, which are at present set for high enough vacuum to function merely as a protective device and, under normal hot water tank operation, are inoperative; and by air vents on the ball float hot water tank traps—a change on these vents to one-way vacuum-type vents would preclude the intake of air at this point. The pressure gage line from header at the 55th floor heating, 19th floor heating, 29th floor hot water and 19th floor hot water are thermostatically trapped in the pump room in the basement and discharge into the sump through a common return line. These traps are open when the steam headers to which they are connected are shut down, and when a vacuum is created in them by condensation, suction occurs back through the pressure gage lines and traps. A check valve has been installed on the discharge line to prevent this condition.

At various points in the system, therefore, air inleakage occurs, immediately after the steam in the radiator system has been turned off. The hot water systems, which operate well into the night—in fact, carry their heaviest load then, due to cleaning operations—discharge into the heating return lines and therefore keep them supplied with hot moist vapors that will provide condensate as they contact cooler surfaces, as a radiator, by being drawn therein by vacuum conditions.

In Building *A*, it is known that the vacuum obtaining shortly after the steam in the radiator system is turned off disappears entirely after a few hours. Thus partial pressure of oxygen in the radiators becomes very large. If the surfaces were dry, any resulting damage would be small, a conclusion fortified by the thousands of radiators that have not given trouble over a period of years. But specifically in Building *A*, connections are so arranged that presumably moisture may condense on the radiator surfaces in the presence of a considerable

partial pressure of oxygen. Hence, while the rate factor of corrosion, as typified by relatively large carbon-dioxide content in the condensate is not high, the quantity factor is unlimited.

It is possible to retard so ready inleakage of oxygen into the system, as indicated previously; it is probably impossible to wholly prevent it. On the other hand, the possibility of hot moist vapor being drawn back into the radiators can be minimized. In both hot water tank rooms there are high pressure drip traps dripping the supply lines from the 90-lb riser to the hot water tank. These traps in turn discharge into a separate so-called high pressure return line which in turn, discharges into the sump, and is independent of the heating system. The pressure in this line is atmospheric at all times. The hot water tank returns can readily be discharged into the high pressure return line, and thus completely isolate the hot water tank returns from the heating system.

The deposits that are found in the nipples therefore have their origin in corrosion of the radiator surfaces. Iron dissolves from these surfaces as ferrous hydroxide, is oxidized to ferric hydroxide, precipitates, and when the water is discharged, is carried along and finds a resting place on the limited surfaces of the nipples. This explanation is in agreement with the fact that the deposits are softer and less dense than those formed *in situ,* and likens the formation of the convolutions on the surface of the deposit to the ripple marks in the sand of the shore. It is interesting to note that after Mr. Finnegan had sawed open a radiator and examined the internal surfaces, he wrote as follows: "The radiator is quite clean, and it is doubtful if enough deposit for analysis can be obtained from it." As the quantity of sample required for analysis is 5 grams or less (less than 1/6 ounce), it is apparent that deposit adherent to the surfaces is well-nigh nil. This is unusual, and is probably the result of the unusual cleanliness of the radiator surfaces, under which condition any moisture is in the form of films and not casual droplets. The absence of pitting on the interior surfaces of the radiator is evidence that dissolution has been general over them, and not merely at points at which droplets of water by collecting expedited union of any dissolved metal with oxygen derived from the contacting vapor.

TABLE 14—DEPOSITS ON NIPPLES FOLLOWING TRAP OUTLET OF RADIATOR

Nos. 1-3 from Building A: No. 4 from Building E

	1	2	3	4
	NIPPLE TO TRAP	ELBOW	NIPPLE FOLLOWING TRAP	COMPARISON NIPPLE
Length, inches	2.64	a	2.43	2.04
Inside Diameter, inches	0.51	0.91	0.52	0.58
Inside Area, sq in	4.23	1.4	3.98	3.71
Wt. Deposit, lb	0.0036	0.0025	0.0030	0.0017
Wt. Deposit, lb per sq in	0.00085	0.0018	0.00075	0.00046
Character of Deposit	Soft	Soft	Soft	Hard
Period of Formation	A few months	A few months	A few months	Seven years

[a] Long radius 2.76 in.
Short radius 1.75 in.
Sector 0.75 in.

Summary and Conclusions

For an intrinsic realization of the factors that control the relations of steam to metal in steam heating systems, certain of the fundamental laws governing solubility in water, and reactions therein must be understood. The earlier part of the report, therefore, has been devoted to consideration of some of these laws, while in the latter part, their application to the specific problems of a steam-generating system and some of its utilizing systems has been pointed out. Both generating and utilizing systems are typical of the modern steam heating industry, hence the conclusions drawn on the data are of general applicability.

When the report was undertaken, it was thought that two general types of problems were involved: (1) formation at various points in the utilizing system of troublesome deposits, the origin of which was primarily carry-over of boiler water and sludge by the steam: (2) corrosive action, and formation of deposits thereby in the utilizing system, with the question to be answered of what responsibility therefore should be borne by the steam furnished by the generating system.

Particularly at Building *A,* the formation of deposits in the utilizing system had been troublesome and had been ascribed to transportation of boiler sludge by the steam. Some months ago, when the inspection of one of the main gate-valves at the 90-lb header showed it to be practically devoid of such deposit, it was suspected that deposits throughout the system had as their origin the metal of the system degraded into such deposits by conditions inherent in the system itself—in other words, that *corrosion,* and not carry-over in the steam, constituted the problems at Building *A,* as elsewhere. The correctness of this suspicion is demonstrated by the analyses of deposits presented in Table 13, which show that all the samples are very high in, and many consist almost solely of, iron oxide.

Therefore, while some general consideration has been given to the elimination of carry-over in the steam, and to the means adopted therefor in this instance by the generating system, the main problem in all cases pertinent to this report has been corrosion.

According to the generally accepted view, corrosion in all cases comprises a *velocity or intensity factor,* and a *quantity factor.* The velocity factor is a function of the *pH* value of water, since rate of dissolution of iron is dependent on this. When the water is condensate derived from steam which was generated from alkaline boiler water, the *pH* value is dependent practically upon the amount of carbon dioxide associated with the steam. The quantity factor is a function of available *dissolved* oxygen, and hence of the concentration and actually available quantity of oxygen in the contacting vapors. From the standpoint of elimination of corrosion, the ideal would be zero intensity and quantity factors; as this is an impossibility in practice, it is necessary to establish for both factors tolerances that provide sufficient limitation thereof to render any corrosive action inappreciable in amount.

The two sources of oxygen and carbon dioxide are the steam and the atmosphere. In the steam, as illustrated at Kips Bay, carbon dioxide predominates in the ratio of 27.5 parts to 1 part of oxygen by weight. In

the atmosphere, oxygen predominates in the ratio of 500 parts to 1 part of carbon dioxide by weight in pure air, and in the ratio of 148 to 1 in the basement of Building *A*. In general, therefore, in Divisions 1 and 2 of the steam heating system, in which no inleakage of atmospheric gases occurs, and in Division 3 as well, so long as inleakage does not occur, the intensity factor of corrosion, as typified by carbon dioxide, predominates in any action on the metal; when inleakage occurs in Division 3, the quantity factor, as typified by oxygen, immediately becomes the mainspring in any corrosion therein, owing to its huge preponderance over carbon dioxide in the atmosphere.

As a limiting concentration of carbon dioxide, the value of 15-20 ppm. has been mentioned as satisfactory. In pure condensate formed from steam of the carbon-dioxide content characteristic at Kips Bay (19.6 ppm.) and unbuffered by any dissolved salts, *pH* values respond by large changes to the slightest traces of alkalinity, and hence any capacity for dissolution of metal is lacking. In fact, in view of the conclusions reached on the basis of the Law of Henry and Dalton, it would seem that greater tolerance would be harmless. On the other hand, if condensation were to occur in dead ends, or at other points, without provision for regulated discharge of any non-condensable gases, the attendant largely increased concentration of carbon dioxide, and at times, of oxygen also, might give rise to conditions favorable to rapid corrosion in quantity. Therefore, since the value of 15-20 ppm. or less of carbon dioxide in the steam is obtained with no difficulty, if sagacious choice is made of a method for processing the feed water, we believe that this value represents a satisfactory tolerance.

In obtaining the concentration of carbon dioxide and of oxygen in the steam, the usual procedure is to condense a sample of steam by passing it through a cooling coil, care being taken that all gases are dissolved in the cool condensate. The determinations for carbon dioxide, oxygen, and *pH* value are then made on this sample. The values so obtained represent truly the composition of the *steam,* but have frequently been regarded as also applicable to *condensate formed from and in contact with the steam.* This is not the case, and the values so obtained do not apply to such condensate. Thus, the *pH* value in samples of condensed steam from Kips Bay Station averaged 5.1, and the carbon dioxide averaged 19.6 ppm.; at the same time, samples of condensate had an average *pH* value of 5.8, and a carbon-dioxide content of 7.6 ppm. These differences occur, because in steam such as that from Kips Bay, the partial pressure of carbon dioxide and of oxygen therein is extremely small.

In any consideration of the relations of steam and metal, therefore, due care must be exercised at all times that proper differentiation be made between the characteristics of the steam itself, and the condensate formed therefrom and in contact therewith.

Probably the greatest need for this discretion arises in connection with appraisals of the relation of oxygen content of the steam to corrosion occurring in the utilizing system. Thus it has frequently happened that steam has been sampled and condensed in a cooling coil as noted above, the oxygen content of the cooled condensate determined, and this value assumed to represent the amount of dissolved oxygen in any condensate formed from and in contact with the steam. The assumption is absurd, because the Law of Henry and Dalton states that the concentration of dissolved oxygen is proportional to the partial pressure of the contacting gaseous oxygen. As a matter of fact, only a very small fraction of the value obtained by the determination on condensed steam will dissolve in condensate formed in contact with the steam, and only in dissolved form is oxygen effective in promoting corrosion.

Limitation of oxygen to the tolerance permissible in the steam is a function of the feed water heater. As previously noted, the lower limit obtainable with deaerating heater is approximately 0.025 ml/liter. This last trace may be removed if desired by chemical fixation following the heater. There is no particular advantage in such complete limitation however, so far as Divisions 1 and 2 of the system are concerned, since even 2 or 3 ml/liter of oxygen in the steam exerts so slight partial pressure, that the quantity factor of corrosion of any condensate in these two divisions is inappreciable. Neither is there any advantage, so far as Division 3 is concerned, until the exclusion of atmospheric oxygen therefrom is made certain. Even at points of condensation under stagnant conditions as in radiators, accumulation of oxygen having its source in the steam, to sufficient partial pressure to provide in the condensate any sizable fraction of its concentration in the steam, is obviated by the blowdown of the vapors in the radiator at times of trap discharge, or charge, or through leak-valves. Besides, these amounts of oxygen are slight in comparison with those in the radiator during off-periods.

One can therefore find no fault with the 0.5 ml/liter of oxygen characterizing the steam furnished Buildings *A* and *B* by the Kips Bay Station. It is true that the condensate drawn at different points in these buildings in Division 3 of the system quite generally was found to have an oxygen concentration of 1 or 2 ml/liter, or even higher; but, in the light of the laws of partial pressure, and of data such as those in Table 12, it is obvious that this concentration of dissolved oxygen is originating not from partial pressures of gaseous oxygen derived from the steam, but from the intrusion into the system of the surrounding atmosphere with its infinitely greater proportion of oxygen.

The responsibility for oxygen so derived rests not with the steam generating system, but with the physical characteristics of the system in the building, such as its type and design, and the quality of workmanship in its assembly, and with the operating practice.

Manifestly, steam of a requisite quality, as defined in the preceding pages, is guilty of no part in the corrosion-activities induced by intrusion of atmospheric oxygen into Division 3 of the system. There is therefore much leeway in choice of the upper limit of tolerance for oxygen. Not from necessity, but from preference, and a desire to be far within any questionable limits, we believe the upper limit of tolerance for oxygen might well be placed at 0.3—0.5 ml/liter, a value readily and assuredly attained.

If, by design of the system, care in its assembly, and choice of operating procedure, the oxygen concentration

in Division 3 of the system could be restricted to that furnished by steam of the quality specified in this report, all problems of corrosion would become of vanishingly small consequence. Although the present-day technique of the well-operated steam generating station could readily and with certainty reduce the concentration of oxygen and carbon dioxide to a tithe of the value specified, to do so is of no practical value so long as the steam passing from Division 2 of the system into Division 3 is degraded in quality by influx of oxygen from the inexhaustible reservoir of the atmosphere, and in amount dependent upon the physical and the operating characteristics of Division 3.

It is in Division 3, or the utilizing system, that any problems of corrosion are apt to become acute. From the very nature of Division 3, it is too much to expect that *all* inleakage of air thereinto can be prevented. Although such inleakage may and does occur in all utilizing systems, in the great majority of cases corrosion is so slight as to be of no moment. When corrosion does occur, it is usually restricted to well-defined areas in the system. It is therefore logical to assume that special conditions exist at such areas for the remedy of which individual measures are required.

In the quest for remedial measures for these cases, it is pertinent to inquire whether district heating steam or steam generated in the individual boiler plant in each building offers any advantages the one over the other in obviating possibility of corrosion. The answer is brief and entirely definite: *The maintenance of the requisite qualifications in the steam, not its source, is the telling factor.*

In the district heating plant, the make-up water is usually large in amount, little condensate being returned to the plant; in the individual plant, the condensate is returned, so that little make-up is required. In either case, the water requires treatment to preserve the evaporative surfaces of the steam generator in satisfactory condition; the same deaeration is required in either case, for limitation of oxygen in the steam is dependent, not on the amount of oxygen in the water entering, but in that leaving the heater; the same precautions are requisite in either case to prevent carry-over in the steam. The same permissible tolerances of carbon dioxide, oxygen and *pH* values in the steam obtain in one case as in the other. Continuously meeting these specifications, the steam, whatever its source, cannot be held responsible for the development of corrosion in the utilizing system.

It would be egregious to suppose that avoidance or solution of these problems of corrosion resides in mere substitution of an individual boiler plant in the building itself in place of the district heating steam. Rather, in so doing, to the problems that are his in any event, the consumer adds that of obtaining the skilled and understanding operation in his boiler room that is pre-requisite to the attainment of specification steam and without which he only multiplies and magnifies his problems.

In the utilizing system, in one method of operation, the pressure is essentially atmospheric at all times; in another, a vacuum is maintained alternating in value between a desired maximum and minimum. In a system operating at atmospheric pressure when the oxygen of the original air in the system has combined with the metal, leaving inert nitrogen, further replacement of the oxygen is dependent in considerable part on the gases from the steam. Thus the oxygen available as a quantity factor in corrosion is relatively limited in amount if proper care is used in production of the steam.

In a system operating under vacuum, continuous removal of the gases in Division 3 is going on. In proportion to leaky connections, open traps, and other paths of entry for the surrounding atmosphere at higher pressure, air enters, and the oxygen concentration constitutes a considerable proportion of the gases in the system. The data of Table 12 are conclusive on this point. The partial pressure of oxygen therein, and hence its tendency to dissolve in the condensate and thus become actively corrosive, are mitigated by maintenance of the vacuum.

In the former type of system, corrosion is more or less limited to the oxygen provided in the steam; in the latter, the relatively low partial pressure and hence restricted solubility of oxygen resultant from the vacuum is the limiting factor. In the former system, when steam is shut off over night, the non-condensable gases should be relatively poor in oxygen and should continue thus; in the latter, the non-condensable gases are well-nigh as rich in oxygen as the atmosphere, and hence if opportunity is given them to dissolve, they should be capable of many times the corrosive activity that would occur if they were largely oxygen-free at the start. In the former, tightness of all connections to the point of preventing gas inleakage is an excellent provision but is not an especial factor in the prevention of corrosion, since pressures within and without the system are the same; in the latter, each connection at which inleakage may occur becomes a potential source of supply for the quantity factor of corrosion. Therefore, in the vacuum system, since continuous maintenance of the maximum vacuum sustains the minimum partial pressure of oxygen in the system, tightness of all the multitudinous connections therein and prevention of oxygen entry through all traps or breather lines becomes a more necessary prerequisite for prevention of corrosion than small differences of a few tenths ml/liter of oxygen in the entering steam.

Despite the amounts of oxygen that are available in the utilizing system because of its operating characteristics, corrosion therein to any troublesome extent is not general, and, as already noted, when it does occur, is usually confined to certain definite areas. This statement applies to both types of system which have just been discussed. Thus the return lines following the trap on the hot-water heater constitute one area of attack; the nipples connecting the radiator traps to the return lines constitute a point for collection of corrosion deposits, although, as illustrated in this investigation, these deposits had their origin probably in the radiator, whence they were transported to the point where found.

The total quantity of oxygen present in the system is not the deciding factor in the amount of corrosion that occurs; only that in dissolved form is effective. For instance, when the steam supply to a radiator is turned off and air is drawn in as condensation occurs, the clean walls of the radiator, drying quickly, are soon im-

mune from attack, whatever the percentage of oxygen present. Over the limited area at the bottom, however, where the condensed water collects, corrosion proceeds. This is in keeping with the observations of Markson and Finnegan regarding a radiator removed from Building *A* for examination, in which a water-line at the bottom was plainly apparent, but corrosion over the surfaces was absent.

A second proviso, therefore, in protection from corrosion, is vested in such arrangement of the system that when the oxygen concentration is apt to be high, continuation of condensation on the surfaces shall not occur. An illustration of this fault was noted in the discussion of the nipple deposits from Building A. Also, drainage should occur as rapidly as possible.

Dry surfaces at the temperatures incident to the utilizing system do not require protection from corrosion, even though the contacting gases contain considerable oxygen. When the surfaces are wetted, and oxygen is present, protective films over the surface of the metal constitute the main defense against all corrosion of all types.

Speller* notes "that steam return lines in systems using exhaust steam from reciprocating engines rarely show serious corrosion, apparently due to the protective effect of a film of heavy hydrocarbon compounds deposited on the inside of the pipe" and notes that "oiling the steam will afford substantial protection to steam piping."

Until recently, the alkalinity of boiler waters has not been exactly controlled; and also, carry-over of boiler water in the steam has been more frequently endured than corrected.

With these conditions obtaining, one is prompted to desire more comprehensive information, in order that decision can be reached whether, in the above instances, protection was afforded by the oil film, or by the maintenance of high *pH* value in the condensed steam by the carry-over of boiler water.

Tests on the advantages and feasibility of so employing oil are to be carried out by the New York Steam Corporation and by The Detroit Edison Company. The results will be awaited with interest.

It may be remarked that this use of oil is antagonistic to that cleanliness of surfaces requisite for rapid and complete drainage thereof. Whether an oil film can be maintained that is free from breaks, and that will protect when droplets of water remain on the surfaces of a radiator, for example, as the concentration of oxygen increases during off periods, must be decided by observation under actual operating conditions.

It remains to discuss how far protection from corrosion can be assured by careful choice of metal to be used in the utilizing system. For absolute assurance of protection, the nature of the material must be such that the service conditions it meets must constitute a minor factor in its service life.

In general, requisite attention paid to the quality of steam, to the tightness of the system and to details in its arrangement such as that of preventing fortuitous condensation of hot vapors on cool surfaces contacting a vapor phase with maximum partial pressure of oxygen, renders unnecessary any general use of materials in the utilization division other than those now employed.

At points in this Division, however, that are particularly susceptible to corrosion, methods of moderating attack to a point of toleration by local use of corrosion-resistant metals seems possible and perhaps advisable. For instance, in the return lines immediately following the hot water heating tanks, the kitchen, the laundry or the mangle, corrosion usually takes the form of grooving or pitting. According to the experience of Markson, a small mechanical change was sufficient to correct conditions following the hot water heater in a typical case of corrosion at this point, and it may be that, in general, a mechanical solution of these cases will be satisfactory. On the other hand, substitution of copper or brass pipes for steel at such points may be advisable, with due attention, of course, to avoidance of bi-metallic contacts at the joints.

Because of the mechanism of formation of the deposits in nipples following the radiator trap, namely, by transportation of the corrosion products from the radiator to the nipple—the utility of substituting brass or copper for steel nipples is not apparent unless the metal of the radiator itself be of non-corrosive characteristics. An answer to this condition consists in limiting the dissolution of metal at the point serving as origin of the corrosion product. Means therefor have been pointed out.

Acknowledgement

When the New York Steam Corporation initiated the investigation of the specific cases of corrosion that constitute the basis of this report, it was agreed that the report should be general, in so far as possible, in its application to corrosion in steam heating lines. With the wealth of accurately taken data provided by the Technical Division of the Corporation, the authors have had opportunity to study these problems on the basis thereof, and to apply thereto, particularly in the utilizing system, the laws of chemical equilibrium. The results have been highly educational, particularly those phases bearing on oxygen and carbon dioxide content in steam, their partial-pressure relationships therein and concomitant solubility in condensate derived therefrom, the different *pH* values that characterize condensed steam samples and condensate derived from the steam. It is our hope that this study will help to correct some of the fallacies that commonly arise from ascribing to the condensate formed from and in contact with the steam those properties found in condensed steam samples.

* Corrosion in Steam Heating Systems, by F. N. Speller (A. S. H. V. E. Transactions, Vol. 34, 1928).

Salts In Boiler Feed Water Reduce Priming

Those who have had much experience with steam boilers know that there are many mysterious cases of the throwing of water into the steam (foaming and priming), that is, water goes into the steam without any apparent reason, says C. W. Foulk, professor of chemistry, Ohio State University, in the *Engineering Experiment Station News*. Now, it follows in all probability that there are also cases in which water is not thrown into the steam, although according to all that is known of the behavior of boiler water it should be. Priming is being studied as part of Engineering Experiment Station Project 103, the investigation of boiler feed waters.

Utilization of Anthracite for Domestic Heating

By Allen J. Johnson[1], Primos, Pa.
NON-MEMBER

THE selection of a fuel is the first logical step in the design of a complete heating system. A knowledge of the burning characteristics of a fuel is essential to such a selection. A series of tests which are now being conducted in the *Anthracite Institute Laboratory* are of especial interest in this connection.

Fig. 1 shows the essential apparatus, which consists of a small space heater placed upon platform scales and connected in such a manner that the net weight of the fuel and ash in the heater can be determined with a practical degree of accuracy. Fuels of various kinds are weighed periodically as they are burned in the heater. By means of the simple expedient of allowing the fuel to create its own draft in conjunction with a permanent stack, comparative combustion results may readily be obtained. Fig. 2 illustrates the rate at which various solid fuels burn, as determined in this manner.

The practical firing interval for a given fuel is directly proportional to the rate of combustion, and very closely linked to the uniformity of burning. For purposes of comparison, the interval between firing attentions which would be practical in order to produce a reasonably uniform amount of heat, is considered to be that part of the run during which the output of the heater is above 75 per cent of the continuous maximum.

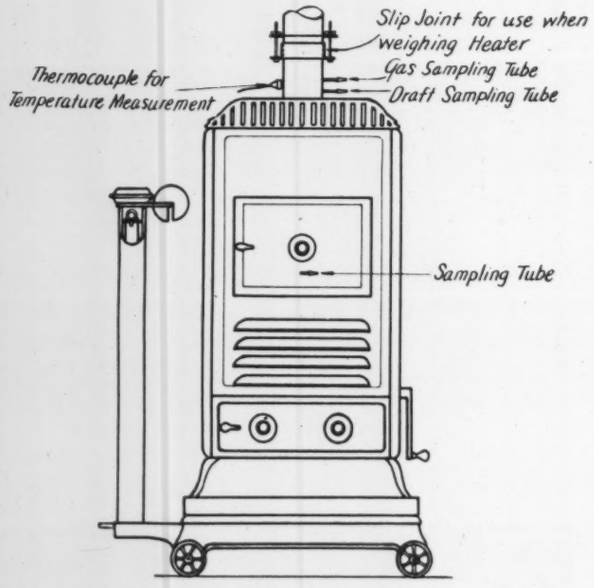

FIG. 1—SPACE HEATER ARRANGED FOR DETERMINING RATE OF COMBUSTION

Another interesting fact which has been disclosed as a result of these experiments is that with anthracite the overall efficiency of the furnace is not materially affected by changes in the stack draft available. This characteristic has an important effect upon the economy of operation, in installations (such as the majority of domestic heating plants) where a continually fluctuating load changes the demand upon the heater. (See Fig. 3.)

Several other characteristics have also contributed to the adaptability of anthracite to domestic use. The low volatile content reduces the possibility of producing smoke, and the low percentage of sulphur results in a corresponding decrease in the production of injurious fumes and odors.

Selection of a Size of Anthracite

The seven sizes of anthracite coal (Fig. 4 and Table 1) provide for its economical and convenient utilization in the particular size and type of heating plant to be employed. It is, however, to the advantage of the consumer to coordinate factors of fuel size and type of heating equipment.

A committee of engineers representing the anthracite producing companies recently agreed unanimously upon preferred uses of the various sizes of hard coal. Their recommendations are as follows:

1. *Egg*, the largest size of domestic anthracite, should be used in fire pots having a diameter of not less than 24 in. and a depth of at least 16 in. The firing of this size in smaller furnaces, while justifiable in some instances, often results in an unnecessary ash pit loss.

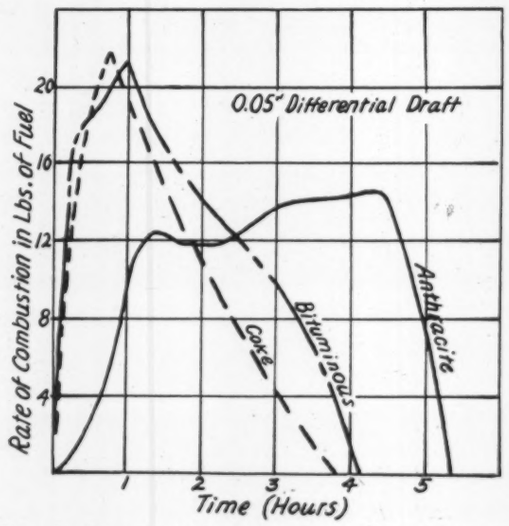

FIG. 2—TYPICAL OPERATION CURVES FOR VARIOUS SOLID FUELS

[1] Director, *Anthracite Institute Laboratory.*

TABLE 1—STANDARD ANTHRACITE SPECIFICATIONS APPROVED AND ADOPTED BY THE ANTHRACITE INSTITUTE

	Test Mesh (Round)	Oversize Maximum	Undersize Maximum	Undersize Minimum
Broken	Through 4⅜ in.	5%		
	Over 3¼ in.		15%	7½%
Egg	Through 3¼ in.	5%		
	Over 2⅜ in.		15%	7½%
Stove	Through 2⅜ in.	5%		
	Over 1⅝ in.		15%	7½%
Nut	Through 1⅝ in.	5%		
	Over 1⅝ in.		15%	7½%
Pea	Through ⅝ in.	10%		
	Over ⅜ in.		15%	7½%
Buck	Through ⅜ in.	10%		
	Over ⅜ in.		15%	7½%
Rice	Through ⅜ in.	10%		
	Over ⅜ in.		15%	7½%
Barley	Through ⅜ in.	10%		
	Over ⅜ in.		20%	10%

2. *Stove* coal is generally suitable for domestic heating plants where the fire pot is 16 in. or greater in width, and 12 in. or greater in depth.
3. *Chestnut* coal is an ideal fuel for domestic heaters of any size where the draft is sufficient. A recent field survey conducted by the *Anthracite Institute Laboratory* disclosed a number of homes in which chestnut was being burned satisfactorily with an average draft of 0.065 in. of water. In several instances drafts as low as 0.034 in. of water were employed without any heating difficulties. Chestnut coal is also a preferred fuel for kitchen ranges.
4. *Pea* coal can be used either in ranges or domestic heaters of any size where the draft is good. The field survey of the *Anthracite Institute Laboratory* showed that with an average draft of 0.07 in. of water, a mean overall boiler and furnace efficiency of 56.7 per cent was being obtained with this fuel. This compares favorably with other sizes of anthracite, and with other fuels.
5. *Buckwheat* is the smallest size that can be burned with natural draft. It is not recommended where the chimney is less than 50 ft. in height, or where the heating plant is naturally overloaded. While it is possible to fire buckwheat upon large mesh grates by carrying a layer of ashes below the active fuel bed it is preferable to insist upon the installation of fine mesh grates when using this size. No. 1 buckwheat coal is also frequently used in magazine feed boilers, mechanical burners, and with forced draft blowers.
6. *No. 2 Buckwheat,* or *Rice Anthracite,* as applied to domestic heating, is used only with mechanical stoking devices.
7. *No. 3 Buckwheat* or *Barley* has no application in domestic heating but is extensively used in manufacturing plants in connection with chain grate stokers.

Mechanical Draft Units

The use of mechanical draft units to accelerate the action of the chimney is a further step in the mechanization of the domestic heating plant. The forced draft blower is very satisfactory for this purpose.

The air capacity of the blower should be selected upon a basis of the total amount of fuel to be burned per hour. In this connection, calculations based upon an average of 13 per cent of carbon dioxide with chestnut coal, 9 per cent with pea coal, and 7 per cent with buckwheat coal, have been found by field engineers of the *Anthracite Institute Laboratory* to approximate those which will be obtained under average conditions of practical operation. (See Table 2.) The use of an oversize blower will result in decreased efficiency due to the presence of a surplus of air, whereas an under-size blower will retard rather than accelerate the combustion of the coal.

The proper ash pit pressure for various operating conditions are of importance in determining the proper type of blower to be employed. Fig. 5 shows recommended pressures at various rates of combustion, and with the different sizes of anthracite.

A third and final factor for consideration in connection with the installation of the blower is its location in the ash pit. Experiments in the *Anthracite Institute Laboratory* have shown that air from a blower will sweep across the ash pit until an obstruction is met, before passing upward through the grates.

For this reason it is desirable to so locate the blower that the greatest volume of air will pass through the fuel bed at a point farthest from the uptake of the furnace. As an example, if the uptake is in the front and

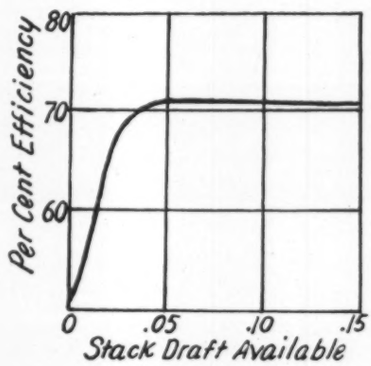

FIG. 3—CURVE SHOWING RELATION BETWEEN DRAFT AND EFFICIENCY FOR ANTHRACITE COAL

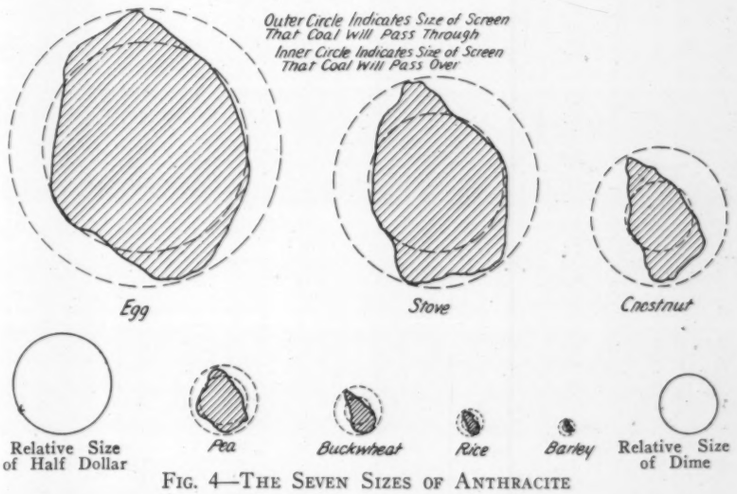

FIG. 4—THE SEVEN SIZES OF ANTHRACITE

TABLE 2—BLOWER CAPACITIES REQUIRED

	NUT	PEA	BUCK
Per cent Carbon Dioxide	13	9	7
Pounds of air per pound of Coal	11.9	17.1	22.0
Cubic feet of air per pound of Anthracite	158	228	294

the blower is affixed to the ash pit door, air for combustion will pass first across the ash pit, through the fire and then across the furnace to the uptake. In such an installation the entire furnace will be swept clean of pockets of gas and a desirable turbulence will be created.

It has been found that attention to this detail of installation is of importance in reducing the tendency toward gas accumulations over the fire. It is, in addition, recommended that a bright spot be kept in the fuel bed for the ignition of gas whenever mechanical draft is employed.

Blowers with Large Coal

Although forced draft units are commonly considered accessories for use in connection with the small sizes of anthracite, their use with pea and even chestnut coal is increasing because of the effectiveness of thermostatic control and the increased overall efficiency of the system. Fig. 8 illustrates this point by comparing the efficiency of natural draft with forced draft units, properly applied to the same boiler. A decided increase in efficiency is noticeable with both the pea and chestnut sizes.

Induced Draft

Several induced draft systems are also available. (Fig. 9.) Difficulties confronting the manufacturer of these units, however, include such factors as installation, protection of the system against the higher gas temperatures which are encountered, and the handling of a greater volume of gas.

Automatic Anthracite Stokers

The final major step in the modernization of a coal-fired heating system is the provision of automatic devices for firing coal, and removing ashes. Three principles of design (Fig. 10), have been incorporated in such devices as applied to domestic use. These are (1) under-feed stokers with combustion taking place in tuyeres, (2) over-feed stokers in which coal is automatically thrown on the fire, and (3) side-feed furnaces in which the fuel is fed at the end or edge of a traveling grate. The sizes and capacities of domestic stokers are given in Table 3.

The under-feed stoker is available in a number of sizes. Capacities of from 250 to 2,000 sq ft of equivalent heating surface (steam) may be obtained in models either with or without mechanical ash removal. As under-feed stokers are designed for installation in existing boilers, the size of the fire pot

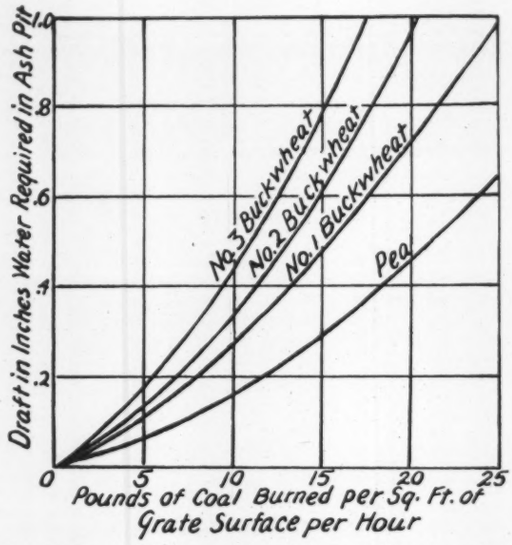

FIG. 5—DRAFT REQUIRED FOR VARIOUS SIZES OF ANTHRACITE

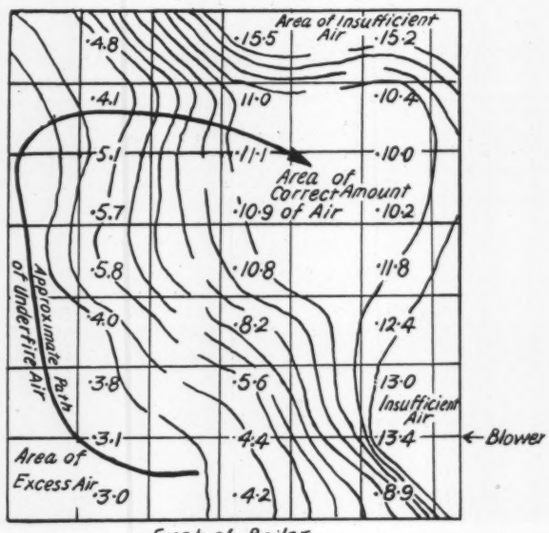

FIG. 6—LINES OF EQUAL AIR DELIVERY THROUGH GRATES OF RECTANGULAR BOILER (BLOWER LOCATED ON SIDE)

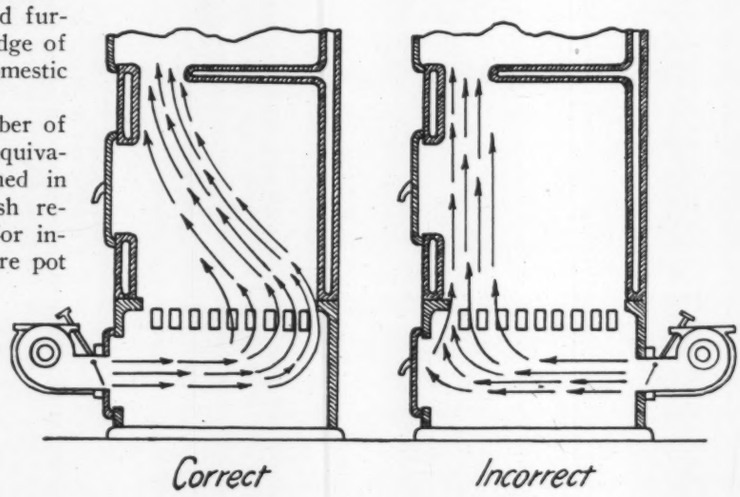

FIG. 7—CORRECT AND INCORRECT BLOWER INSTALLATIONS

must be taken into consideration. Present practice divides under-feed stokers into two types:

1. Those in which ash falls over the edge of the fire pot by gravity.
2. Those provided with revolving grates or with a revolving arm which scrapes the ash into a receptacle or opening for removal.

In the first type it is essential that a minimum distance of at least 3 in. be provided upon all sides of the stoker tuyere pot, in order to preclude the possibility

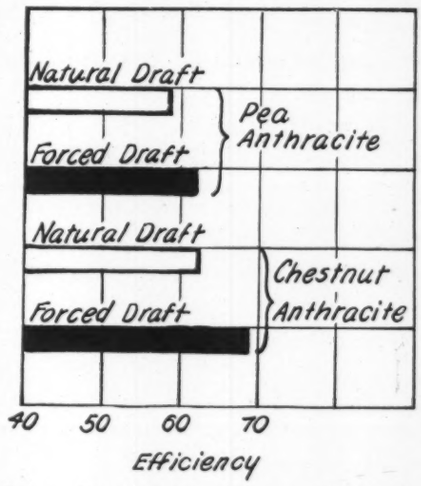

Fig. 8—Relative Efficiency of Forced and Natural Draft for Two Sizes of Anthracite

of ash accumulating above the grate. In the second or mechanical scraping type, smaller clearances can be employed which in some cases enable the installation of a stoker in furnaces having a diameter but slightly in excess of the stoker tuyere pot.

The limitations of a round tuyere box in long narrow rectangular boilers are centered around the fact that the installed stoker capacity cannot exceed that of the largest circle which can be inscribed in the rectangle, minus a space for ash for clearance. Attempts to overcome this difficulty have been made by (1) installing two stokers in the same furnace, (2) by installing a stoker having two circular fire pots instead of one, and (3) by installing a stoker having a relatively narrow elliptical fire pot. (See Fig. 11.)

The operation of domestic stokers may be divided into two classes:

1. Stokers operated intermittently by means of thermostatic control.
2. Stokers designed to operate continuously.

Continuous operation possesses the advantages of overcoming heating sluggishness in residences which have inadequately sized heating mains or poorly placed heating units. Overheating and periods of unequal heat are also reduced to a minimum.

Intermittent systems are usually set to accommodate the full heating load of the building under the maximum demand. Their

Table 3—Sizes and Capacities of Domestic Stokers
(Gravity Ash Disposal from Firepot)

Boiler[a] Size Inside	Maximum Tuyere Size	Radiation at Maximum Efficiency	
		Steam	Water
16	9	188	300
18	12	320	500
20	14	460	725
22	16	700	1100
24	18	850	1350
26	20	920	1500
28	22		

[a] Inside dimensions—
Diameter—Round Boiler
Smallest Side of Rectangular Boiler

operating factor under normal conditions is therefore but a fraction (usually from ⅓ to ¼) of the total heating season. As a result the electrical consumption is materially decreased, and economy is obtained due to the light demands upon the burner during the spring and fall. There is also a possible increased life of the machine due to its part time operation.

The stoppage of a domestic stoker results in a dormant or banked condition of the fire which utilizes sufficient fuel to maintain warmth within the furnace without rapid extinguishment. Fig. 12 illustrates this point by showing that after a period of idleness of 17 hours operation for thirty minutes brought the fuel bed to a normal condition.

Over-feed Stokers

The over-feed stoker is available in designs which include plungers for forcing the coal into the furnace of standard boilers or flippers for accomplishing the same purpose. Advantages of this type include its adapta-

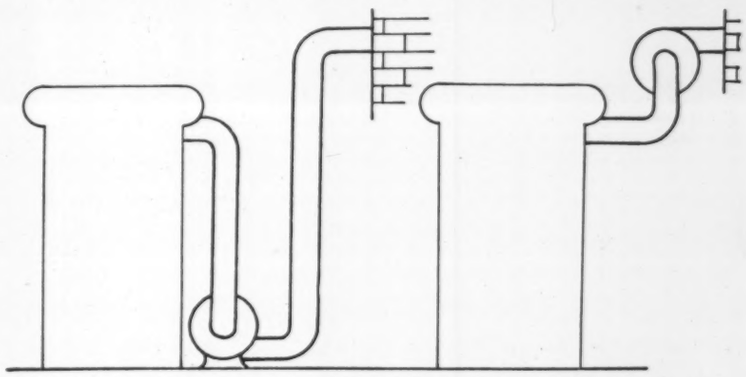

Fig. 9—Two Types of Induced Draft Installations

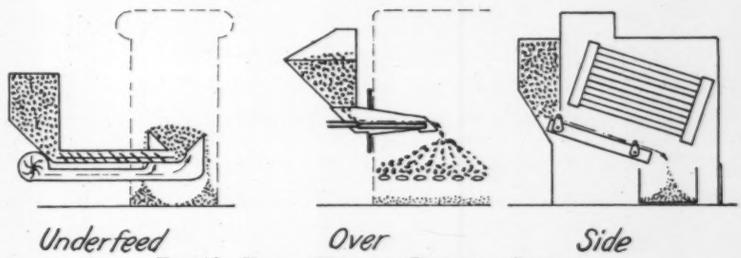

Fig. 10—Three Types of Domestic Stokers

bility to all sizes of coal, and to all types of heating equipment. The system is also more mobile, and in the event of power failure can usually be readily removed for hand firing. Disadvantages include the fact that as at present designed the grate shaking and ash removal must be given the same attention as with hand firing.

Side-feed Stokers

At the present time at least two models employing the side-feed principle are available. One of these includes a reciprocating grate which carries the coal from a hopper at one end of a special tubular boiler to an ash can located at the rear. The second type employs a revolving grate with an eccentric action which pushes coal fed at the circumference gradually to a circular hole in the center of the grate.

Both of these stokers require the use of a specially designed boiler. Their advantages include adaptability to all sizes of coal and, due principally to a coordination of the grate and boiler, to an increased efficiency as compared with other automatically-fired units.

Magazine Feed Boilers

Magazine feed boilers increase convenience in connection with the utilization of anthracite by providing a coal storage space as an integral part of the boiler. Firing attention is decreased by the use of inclined grates designed to facilitate the feeding of coal from the storage hopper by gravity as it is consumed.

Sizes and Capacities

Magazine feed boilers are available in sizes ranging from 390 sq ft to 15,000 sq ft. The coal storage capacity of this type of boiler is proportional to the size of the unit. However, for estimating purposes, it may be assumed to be one pound of coal storage capacity for each

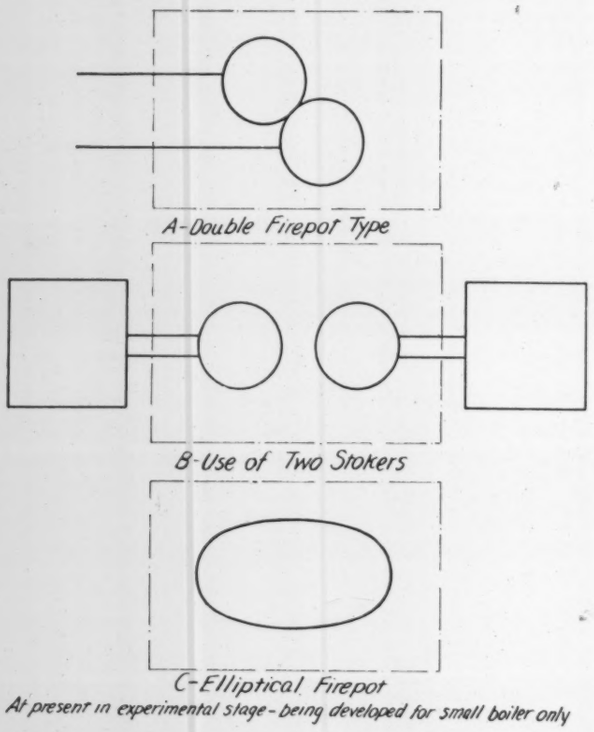
A-Double Firepot Type
B-Use of Two Stokers
C-Elliptical Firepot
At present in experimental stage - being developed for small boiler only

FIG. 11—METHODS OF INSTALLING STOKERS IN NARROW RECTANGULAR BOILERS

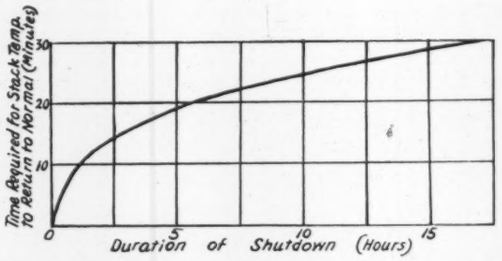

FIG. 12—TIME REQUIRED FOR STOKER RECUPERATION AFTER VARYING SHUTDOWNS

2 sq ft of heating surface supplied. On this basis sufficient coal is contained in the hopper for 14 hours of continuous operation for an outside temperature of zero or for 32 hours of continuous operation for an outside temperature of 40 F.

Manual Attention

By reason of the inclined grate and storage magazine, manual attention is, in normal weather, reduced to an infrequent shaking of the grates and to a periodical replenishment of fuel and removal of ashes. While not as free from the necessity for manual attention as the mechanical stoker, the simplicity of magazine boilers together with lower cost and absence of moving parts have increased their use.

Draft Required

Inasmuch as the magazine feed type of boiler is a natural draft device, designed for the smaller sizes of coal, care should be taken to provide adequate draft. Forced draft, while sometimes employed, is not desirable because of its tendency to drive the fire into the storage magazine with a resultant emission of gas.

Banking Advantage

The adaptability of the magazine feed boiler to prolonged banking periods without a burning out of the fire is an added advantage of considerable importance. This is particularly true in schools, office buildings, or other installations where week-end banking is desirable.

Automatic Heating with Anthracite

The availability of equipment such as has been described has made automatic heating with anthracite an economical reality.

The normal capacity of stoker and magazine boiler hoppers may be depended upon for supplying heat without manual attention for periods of from 24 hours to several days (depending upon the rate at which the boiler is operated). During one series of tests in the *Anthracite Institute Laboratory* a stoker was set at a rate which approximated the heat demand of the building and left unattended over a holiday, without thermostatic control. Although the outside temperature dropped 23 deg during this period, the stoker maintained the building temperature at 70 F during the entire period.

In several instances coal bins have been designed to feed directly to the stoker worm, thus providing complete automatic control in a non-mechanical manner. Conveying equipment to fill stoker hoppers from the coal bin and special ash nozzles to fill seven large cans in turn are available as standard accessories.

NOMINATIONS FOR 1932

The Nominating Committee appointed to select candidates for Officers of the Society for the coming year, 1932, takes pleasure in submitting the following list of nominees:

For President:

F. B. ROWLEY, Minneapolis, Minn.

For First Vice-President:

W. T. JONES, Boston, Mass.

For Second Vice-President:

C. V. HAYNES, New York, N. Y.

For Treasurer:

F. D. MENSING, Philadelphia, Pa.

For Members of the Council:

Three-Year Term

F. E. GIESECKE, College Station, Texas.
G. L. LARSON, Madison, Wis.
J. F. MCINTIRE, Detroit, Mich.
W. E. STARK, Cleveland, Ohio

Respectfully submitted,

NOMINATING COMMITTEE

R. C. BOLSINGER, *Chairman*

Chapters	*Representative*
Cleveland	H. M. NOBIS
Illinois	H. M. HART
Kansas City	N. W. DOWNES
Massachusetts	DAVID MOULTON
Michigan	J. F. MCINTIRE
Minnesota	M. S. WUNDERLICH
New York	RUSSELL DONNELLY
Western New York	F. H. BURKE
Ontario	H. J. CHURCH
Pacific Northwest	E. O. EASTWOOD
Philadelphia	R. C. BOLSINGER
Pittsburgh	F. C. MCINTOSH
St. Louis	C. A. PICKETT
Southern California	R. L. GIFFORD
Wisconsin	E. A. JONES

In accordance with the provisions of the Amended Constitution, as given, ballots containing the names of the above candidates will soon be sent to the membership for voting upon prior to the Annual Meeting in January.

Art. 9—*Section* 2. The Nominating Committee shall consist of a member designated by each Chapter, which shall effect its own organization and elect its own Chairman.

Section 3. The Committee may meet at the call of the Chairman, for discussion, but the official meeting shall be held at the Semi-Annual Meeting of the Society, at which time the candidates for each of the offices of the Society to be filled at the next Annual Meeting shall be selected by a majority vote of the members of the Committee present and voting. Five shall constitute a quorum.

Section 4. The Committee shall first secure the consent of all candidates selected, and shall, if possible, announce the names of the candidates at the Semi-Annual Meeting, but in any case the names of the candidates shall be certified to the Secretary of the Society at least four months before the next Annual Meeting. The Secretary shall publish these names in the October issue of THE JOURNAL.

Art. 10.—*Section* 3. The Secretary shall prepare ballots with the names of all candidates and forward them to the members at least thirty (30) days before the date of the Annual Meeting.

Nominations for Members of Committee on Research

Although committees of the Society are usually appointed, in view of the great importance of the Committee on Research and the financial responsibility it would be called upon to assume, it has been made more representative of the entire membership of the Society by a process of *election*. The election is governed by the By-Laws for the election of officers, with the single exception, that Members of the Committee on Research are nominated by the Council instead of by a Nominating Committee.

In accordance with the Regulations for the government of the Research Laboratory, adopted at the January, 1919, Meeting, and revised January, 1930, the Council announces the nomination of the following members of the Committee for election to succeed those members whose present terms expire January, 1932:

D. E. FRENCH, Philadelphia, Pa.
F. E. GIESECKE, College Station, Texas
A. P. KRATZ, Urbana, Ill.
G. L. LARSON, Madison, Wis.
L. A. HARDING, Buffalo, N. Y.

The regulations governing the nomination and election of members of the Committee on Research are as follows:

SECTION I—ORGANIZATION

Research Committee

1. There shall be a standing committee known as the Research Committee, consisting of fifteen members, each serving for three years, and five retiring each year.

a. The Council shall nominate previous to October first of each year five members to fill the vacancies of those retiring at the next Annual Meeting.

b. The nominations made by the Council shall be published in the October issue of the Society's JOURNAL.

c. Prior to December first of any year, any ten members, over their own signatures, may nominate one or more additional members of the Research Committee, and such additional nominations shall be placed on the ballot opposite the nominations made by the Council.

d. The election shall otherwise conform to the regulations provided for the election of officers of the Society.

e. Vacancies may be filled by the Council, such persons chosen by the Council to serve until a successor is elected at the next Annual Meeting.

CLEVELAND PUBLIC SQUARE, SHOWING PROXIMITY OF PUBLIC AUDITORIUM TO DOWN-TOWN SECTION

Cleveland is Ready for Meeting and Exposition

PLANS have been made for a warm welcome to Cleveland January 25 to 29, 1932, when the 38th Annual Meeting of the Society and 27th Annual Meeting of the *American Society of Refrigerating Engineers* will be held at the Hotel Statler and the Hotel Cleveland, respectively. Joint sessions for the members of the two Societies have been arranged and the members also will visit the Second International Heating and Ventilating Exposition in the Cleveland Auditorium. Chairman T. A. Weager of the Committee on Arrangements announces the completion of plans for entertaining the visitors and a record attendance is expected.

Application has been made for fare-and-one-half for Society members on the *Identification Certificate Plan* assuring them of reduced rates for their trip to the meeting.

Members will receive through the mail announcements about points of interest to be seen in Cleveland, information regarding railroad schedules, and rates, hotel reservation cards and railroad certificates. The schedule of mailings proposed by the Publicity Committee, headed by M. F. Rather, provides for sending announcements and information to members and guests on December 1, December 15, December 29, 1931, January 4 and January 15, 1932.

In accordance with the usual custom no fees will be charged and attendance at the banquet and other social functions will be optional. The banquet program will be directed by W. C. Kammerer and his committee and the special entertainment features for members and ladies comes under the jurisdiction of R. G. Davis and his associates.

The first members to reach Cleveland will be greeted by the Reception and Registration Committee, which is organized under the direction of C. F. Eveleth. For those who desire to participate in the various inspection trips, F. H. Morris and his associates are arranging transportation.

The Technical Program will be presented at the morning sessions and the only afternoon session scheduled is on Thursday, when the report of the Committee on Ventilation Standards will be considered.

The entire day of Monday, January 25, has been reserved for Committee Meetings. The first Technical Session will be held Tuesday morning in the Hotel Statler with Pres. W. H. Carrier presiding and reports of the Tellers-of-Election, Officers and Council will be given. Wednesday morning the sessions will be held in the Little Theatre of the Cleveland Auditorium and it will be a joint meeting with the *American Society of Refrigerating Engineers,* the program being conducted under the direction of Pres. W. H. Carrier.

Again on Thursday, the second joint session of the organizations will be held in the Little Theatre of the Cleveland Auditorium and the program sponsored by the *A. S. R. E.* will be presided over by Glen Muffly. The A. S. H. V. E. afternoon session on Thursday will be held in the ballroom of the Hotel Statler and besides the technical papers, the report of the Committee on Ventilation Standards will be given.

The Friday morning session, commencing at 10:00 a. m., will be held in the ballroom of the Hotel Statler and following the presentation of the technical features, the installation of Officers will be made.

The technical program has been prepared with a view toward the presentation of subjects of particular interest with adequate time for the presentation of discussions. The subjects to be offered include heat transmission investigations, acoustical problems, research in pipe capacities, mechanical warm air heating and ventilating systems, combustion, field and laboratory studies of corrosion and operating data on air conditioning and cooling.

The plans for Cleveland indicate that it will be the capital of the heating world during the week of January 25, 1932, and every member is urged to be present.

CLEVELAND AUDITORIUM

PRELIMINARY PROGRAM

38th ANNUAL MEETING

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

January 25-29, 1932
Hotel Statler, Cleveland, Ohio

Monday—January 25th

10:00 A. M.—Meeting of the Council

12:30 P. M.—Luncheon for Officers and Authors

2:00 P. M.—Meeting Committee on Research

7:00 P. M.—Joint Dinner-Meeting of the Councils of the A. S. H. V. E. and *A. S. R. E.* and their wives (Hotel Cleveland)

Tuesday—January 26th

10:00 A. M.—First Session (Ballroom Hotel Statler)
Address of Welcome
Greeting by Pres. W. H. Carrier
Report of Tellers of Election
Report of Council

Technical Papers:

Surface Coefficients as Affected by Direction of Wind, by F. B. Rowley and W. A. Eckley

Conductivity of Concrete, by F. C. Houghten and Carl Gutberlet

Report of the Finance Committee

Report of the Secretary

2:30 P. M.—Inspection of Second Heating and Ventilating Exposition

9:00 P. M.—Informal Reception including entertainment and Monte Carlo (Ballroom Hotel Statler)

Wednesday—January 27th

10:00 A. M.—Second Session (Cleveland Auditorium)
Joint Meeting with *A. S. R. E.*—Program arranged by A. S. H. V. E.—Pres. W. H. Carrier presiding

Technical Papers:

Field Studies of Office Building Cooling, by S. S. Sanford, E. P. Wells and J. H. Walker

Acoustical Problems in Heating and Ventilating of Buildings, by V. O. Knudsen

Changes in Ionic Content of Air in Occupied Rooms Ventilated by Natural and by Mechanical Methods, by C. P. Yaglou, L. C. Benjamin and S. P. Choate

Heat Capacity of Building Walls, by F. C. Houghten

2:00 P. M.—Trip to Akron (Goodyear-Zeppelin Hangar)

7:00 P. M.—Dinner for Past-Presidents (Hotel Statler)

8:00 P. M.—Ladies' Theatre Party at Keith's Palace

8:00 P. M.—Inspection of Second Heating and Ventilating Exposition

Thursday—January 28th

10:00 A. M.—Third Session (Cleveland Auditorium)
Joint Session with *A. S. R. E.*—Program arranged by *A. S. R. E.*—Glen Muffly presiding

2:30 P. M.—Fourth Session

Technical Papers:

Some Fundamental Considerations of Corrosion in Steam and Condensate Lines, by R. E. Hall and A. R. Mumford

Friction in Tees, by F. E. Giesecke and W. H. Badgett

7:00 P. M.—Annual Banquet and Dance (Hotel Statler)

Friday—January 29th

10:00 A. M.—Fifth Session (Hotel Statler)

Technical Papers:

A Study of the Combustible Nature of Solid Fuels, by R. V. Frost

Installation of Officers

Resolutions

Adjournment

12:30 P. M.—Luncheon and Meeting of Council

2:30 P. M.—Inspection Trip to Cleveland Industrial Plants

COMMITTEES

T. A. Weager, *General Chairman*

Finance: Walter Klie, *chairman;* W. E. Stark and H. M. Nobis.

Banquet: W. C. Kammerer, *chairman;* C. W. St. Clair and Vincent Eaton.

Reception and Registration: C. F. Eveleth, *chairman;* F. A. Kitchen and C. Gottwald.

Transportation and Inspection Trips: F. H. Morris, *chairman;* C. J. Deex and J. E. Beyer.

Entertainment: R. G. Davis, *chairman;* E. H. Pogalies and S. H. Givelber.

Publicity Committee: M. F. Rather, *chairman;* Akron District, D. E. Humphrey; *A. S. R. E.*, D. F. Keith.

Bridge Hostesses: Mrs. Walter Klie, Mrs. T. A. Weager, Mrs. H. B. Matzen, Mrs. D. F. Keith, Mrs. C. F. Eveleth and Mrs. C. W. Colby

Local Chapter Reports

Cleveland

October 7, 1931. The Cleveland Chapter opened the 1931-32 season with a meeting at the Cleveland Engineering Society at which 120 members and guests were present.

The principal speaker of the evening was Pres. W. H. Carrier, of the Society, who spoke on Servicing the Human Power Plant. This talk was well illustrated by lantern slides and was listened to attentively by those in attendance. Mr. Carrier's discussion was based in part upon investigations at the Research Laboratory of the Society and at the Harvard School of Public Health. The proper air conditions to be maintained were discussed, particularly with reference to proper air distribution.

A. V. Hutchinson, national secretary, was present and talked briefly on the research work of the Society and on its program for increasing membership.

Pres. W. E. Stark, of the Cleveland Chapter, outlined the program for the current year and discussed the work of the new committees. Mr. Stark also spoke to those present regarding the 38th Annual Meeting of the A. S. H. V. E. to be held in Cleveland, January 25-29, 1932, at the same time as the Second International Heating and Ventilating Exposition.

After a vote of thanks had been given to President Carrier the meeting was brought to a close.

Massachusetts

November 3, 1931. A luncheon meeting, presided over by President David Moulton, was held at Durgin Park restaurant and was attended by 24 members and guests of the Massachusetts Chapter.

F. R. Ellis introduced Edward O. Otis, Jr., merchandising advisor to the Associated Industries of Massachusetts, who spoke on Engineering Consumption. Mr. Otis held the attention of his audience throughout his talk and the interest shown was evidenced by an open discussion.

The Chapter was grieved to learn of the serious illness of W. T. Smallman, a life member of the Society, who has undergone an operation at a Boston hospital. A letter to Mr. Smallman will be followed by personal visits from several members representing the Chapter.

Leslie Clough, Secretary, outlined the plans of the Board of Governors for determining the extent of the unemployment situation existing among Chapter members.

Illinois

October 12, 1931. At this meeting of the Illinois Chapter, held in the Morrison Hotel, Chicago, with 57 members and guests in attendance, Prof. G. L. Larson of the University of Wisconsin was the speaker of the evening. Professor Larson delivered an address on Some Research on Air Infiltration and Air Movement and at the conclusion of his talk was given a rising vote of thanks for his splendid discussion.

With Pres. A. G. Sutcliffe presiding, the secretary read a report of the activities of the Chapter during the past season and a financial report was given by the treasurer.

The Committee on Revision of By-Laws submitted a report through its chairman, M. S. Good, who read a resumé of the report, directing attention to the revisions made. The chair announced that the incoming directors would receive the report.

A communication regarding Society Research Activities in 1931 from C. V. Haynes and S. R. Lewis was read by S. I. Rottmayer.

President Sutcliffe asked for an expression of opinion regarding the new dinner and meeting arrangement and it was voted that the arrangement be continued.

The Tellers of Election, E. P. Heckel, B. A. Broom and J. J. Haines, reported the results of the election as follows:

President—John J. Aeberly.
Vice-President—J. H. O'Brien.
Secretary—C. W. DeLand.
Treasurer—C. W. Johnson.
Board of Governors—H. P. Reid, Eugene Mathis, and A. G. Sutcliffe.

The new officers were conducted to the speakers' table and spoke briefly.

President Aeberly then declared the meeting adjourned.

Kansas City

October 12, 1931. Thirty members and several guests met at the Ambassador Hotel where the meeting of the Kansas City Chapter was presided over by E. K. Campbell in the absence of both Pres. J. M. Arthur, and Vice-Pres. William Russell.

The Chapter members welcomed C. W. Butler, formerly of the St. Louis Chapter, and several guests, among whom were Messrs. Filkin, vice-president and chief engineer of the City Ice Co., Seigher, manager of new production, and Bush, chemist of the same company.

N. W. Downes gave a thorough analysis of the Kansas Engineers Licensing Bill No. 159 and a general discussion of the bill followed.

A representative from the Charities Organization spoke forcibly on the pressing need of an extra effort to relieve suffering this winter on account of unemployment, which has not as yet been felt in full because of a hangover in building which is now rapidly reaching completion.

E. K. Campbell read a communication and report from C. V. Haynes, Chairman of the Society's Committee on Research, and proposed that the chapter assist in a phase of research of which Mr. Campbell is chairman of the Technical Advisory Committee. An effort will be made at Kansas University under the direction of Professor Sluss to determine suitable methods for the ventilation of garages, and the chapter voted to give $75.00 to this research work.

Arthur Hardgrave, who has been closely associated with practically all civic effort in Kansas City in the last nine years, was the speaker of the evening and gave a most interesting and enlightening talk on space cooling for comfort, discussing particularly the application of ice to cooling systems for this purpose. A very able presentation of this subject was given, including facts and figures on installations. A discussion followed in which Mr. Hardgrave answered many questions relating to good practice, economics, actual installations, etc. The speaker was also induced to tell those present how he became interested in aviation and he related a number of interesting experiences.

Michigan

October 12, 1931. A dinner meeting of the Michigan Chapter was held at the Cadillac Athletic Club with 65 members and guests present and with Pres. G. H. Giguere presiding.

The principal speaker of the evening was W. H. Carrier, President of the A. S. H. V. E., who, in spite of illness, gave a very fine address on, The Requirements and Standards of Ventilation.

A. V. Hutchinson, national secretary, spoke of the work and programs of other chapters and told of the Annual Meeting to be held in Cleveland, January 25-29, 1932.

A past president of the Society, J. R. McColl, told of the forming of a new chapter at Grand Rapids, Mich., during the previous week.

After considerable discussion on the various subjects presented, the meeting was adjourned.

St. Louis

October 14, 1931. Sixty-two members and guests were present at the St. Louis Chapter meeting and dinner which was held at the Roosevelt Hotel.

Due to the large number of guests in attendance, many of whom were members of the *American Society of Refrigerating Engineers,* Pres. R. M. Rosebrough announced that the usual order of business would be postponed.

W. H. Carrier, national president, was then introduced and spoke on Servicing the Human Power Plant. Mr. Carrier's address was greatly appreciated by those present and after closing his talk he discussed many questions pertaining to air cooling and distribution as well as proper standards of ventilation now under consideration of a Society Committee.

New York

November 16, 1931. Three hundred members and guests participated in the November meeting of the New York Chapter, held at the Building Trades Club, New York, jointly with the Metropolitan Section of the *A. S. M. E.* Among the invited guests were members of the New York Chapter, *A. I. A.,* Building Managers Section of the New York Real Estate Board and men interested in district heating.

The subject of the evening was Corrosion in Steam and Condensate Lines and was presented by A. R. Mumford, New York, Research Engineer of the New York Steam Corp., and the discussion was conducted by Dr. R. E. Hall, Pittsburgh, Pa., the co-author of the paper. Lantern slides were used to illustrate the solvent action of water in the steam heating cycle and to show the results of an analysis of conditions existing in the steam generating, distributing and utilizing systems. Data from various buildings were given and proved of great interest.

Prepared discussions were submitted by Messrs. Artsay, Gates, Orrock and Ricketts. In the verbal discussion, participants were Messrs. Blizard, Harsen, Kreisinger, Shoudy, Cohen, Martin, Applebaum, Timmis, Palmer and Pendleton.

W. H. Driscoll, past-president of the A. S. H. V. E., conducted the meeting as toastmaster, and congratulations were given to Messrs. Keenan, Donnelly and Ehrlich for arranging the evening's program. A typical Forbes dinner was served before the presentation of the technical subject.

Philadelphia

October 8, 1931. The meeting of the Philadelphia Chapter was held at the Engineers Club and was called to order by Pres. E. N. Sanbern.

The minutes of the previous meeting and the Treasurer's report were read and approved.

Mr. Sanbern introduced John L. Grimes, of the Wheeling Steel Corp., who presented a film entitled, Steel Making from Mine to Market. The picture was most interesting and showed the making of steel sheets and pipe from the ore mines until its installation for various purposes.

The remainder of the meeting was devoted to the subject of Fans and Their Proper Application to Ventilating Systems, by Benjamin J. Adams, a chapter member, who gave a most interesting talk on the designs of different types of fans, their characteristics, and the application of the different types to ventilating work. L. C. Davidson spoke briefly on Fan Characteristics and Design.

J. H. Hucker, chairman of the Meetings Committee, announced that the next meeting would consist of a discussion between two architects, two engineers and two contractors, whose names would be announced later.

F. D. Mensing spoke briefly about the A. S. H. V. E. Research Laboratory and explained its object and the many advantages and forward strides in the heating and ventilating industry that have been made possible as a result of its findings.

At the conclusion of Mr. Mensing's talk, the meeting was adjourned.

Western New York

October 12, 1931. The first fall meeting of the Western New York Chapter was held at the Hotel Buffalo, preceded by a dinner attended by 30 members.

The Chapter was privileged to hear an illustrated address by L. A. Harding on the Utilization of the Sun's Energy, presented in the characteristic Harding manner. The subject matter was most interesting and struck a responsive chord in the audience as was evidenced by the discussion which followed. The Chapter expressed its gratitude to Mr. Harding for his presence at the meeting and for the information which he gave.

A recent report of research activities in 1931 was read by M. C. Beman.

Plans are now under way for a large attendance at the November meeting when the Chapter will be host to the National Officers and Council of the Society.

Southern California

November 10, 1931. Forty-two members and friends were the guests of the Natural Gas Bureau in Los Angeles at a dinner meeting. After a delightful dinner and entertainment by the Hill Billies a most interesting after-dinner talk was given by Jim Foley, nationally known humorist and story teller.

A short business meeting was held at which the results of the election were announced as follows:

President—Franklin R. Winch.
Vice-President—L. H. Polderman.
Secretary—Edwin H. Kendall.
Treasurer—Leo Hungerford.
Board of Governors—M. M. Lawler, W. H. Ness and O. W. Ott.

H. L. Warren, heating engineer for the Los Angeles Gas & Electric Corp., presented a paper on Gas and Its Application to Heating, Cooling and Air Conditioning with Special Reference to silica gel. This paper was very interesting and was followed by considerable discussion.

Death of Frank Huckel, Jr.

Frank Huckel, Jr., a member of the Society since 1920 and widely known to the heating industry, died on October 16, 1931.

Mr. Huckel was born in Philadelphia in 1883 and lived there until his death. His first training and professional experience he received when he was employed by the Isaac A. Shepard Co., boiler manufacturers in Philadelphia. After four years he became associated with the Lehigh Valley Railroad Co., leaving it to accept a position with the Model Heating Co., where he remained for seven years, rising from the position of clerk to salesman and heating engineer.

In the year 1915 he joined the staff of the Keystone Supply & Mfg. Co., having charge of its heating department, remaining with that company until 1927, when the Keystone Supply & Mfg. Co., through a merger, became part of the Hajoca Corp.

Mr. Huckel continued with the new corporation until 1929, when he severed his connections to take charge of the heating department of the J. D. Johnson Co.

News of Mr. Huckel's sudden death came as a great shock to his many friends in the heating industry and to his fellow members in the Society.

Of Interest to Members

Progress of Ventilation Standards

The Committee on Ventilation Standards held a meeting at the Hotel Statler, Buffalo, N. Y., on November 9, with W. H. Driscoll, chairman, presiding and the following members in attendance: J. J. Aeberly, F. Paul Anderson, J. R. McColl, C. L. Riley, W. A. Rowe and A. C. Willard.

A summary of the replies to a letter sent to members was presented and the many ideas and suggestions proposed were considered at an all day session of the committee and a revised report is to be prepared for the Annual Meeting in Cleveland.

New Offices for Richardson & Boynton

On November 16 new headquarters for Richardson & Boynton Co., manufacturers of heating and cooking apparatus, were opened at 244 Madison Ave., New York City. A general display room and executive offices are maintained in these larger quarters, which also give opportunity for further expansion. The location in the heart of the architectural business zone is an added advantage, according to the announcement.

Meeting of Committee on Research

On November 10 the Committee on Research convened at the Hotel Statler, Buffalo, N. Y., with the following men present; C. V. Haynes, *Chairman*, C. A. Booth, F. C. Houghten, W. T. Jones, J. F. McIntire, F. B. Rowley, A. E. Stacey, J. H. Walker, Perry West, A. C. Willard, P. D. Close, and, by invitation, W. H. Carrier, J. J. Aeberly, and L. A. Harding.

During a full day's session the committee considered a number of important projects and among those of outstanding importance were: Report on Current Research Activities, Financial Report and Budget, Appointment of Finance Committee, Exhibit at Heating and Ventilating Exposition, Co-operative Agreements with Colleges, Completion of Projects at Pittsburgh Laboratory, Future Program of Research Laboratory, Review of Proposed Research Projects, and Nomination of Chairman of Committee on Research for 1932.

Council Meeting in Buffalo November 9

On November 9 the Officers and Council of the Society gathered at Buffalo for a regular meeting and approved the proposed program for the Annual Meeting of 1932 in Cleveland.

The special committee appointed in June at Swampscott to revise the contract for publishing the Journal presented the executed contract and the committee was thanked for its service and discharged.

The dates of the next Summer Meeting, to be held in Milwaukee under the direction of the Wisconsin Chapter, will be June 27, 28 and 29 and headquarters selected by the Milwaukee members will be maintained in the Hotel Pfister.

A recommendation was made to the Committee on Research to provide an adequate exhibit at the Second International Heating and Ventilating Show in Cleveland during the week of January 25 and funds were designated for this purpose.

A petition was granted for a Western Michigan Chapter of the Society with headquarters in Grand Rapids.

The Report of the Committee on Code for Testing and Rating Unit Ventilators was presented and after considerable discussion W. A. Rowe was designated to communicate with Chairman John Howatt in respect to the publication of the code in advance of the Annual Meeting.

The Report of the Committee of Award for the F. Paul Anderson Medal was presented by Chairman A. C. Willard and its recommendations are to be voted on by ballot in accordance with the procedure outlined in the Rules of Award.

Several communications were presented and routine action was taken in accepting the resignation of 21 members, the reinstatement of 3, and voting Life Membership to 8 Charter Members as follows: Homer Addams, George C. Blackmore, J. J. Blackmore, A. C. Edgar, C. F. Hauss, George Mehring, D. M. Quay and P. H. Seward.

Those Officers and Members of the Council who participated in the meeting were W. H. Carrier, President, F. B. Rowley, 1st Vice-President, W. T. Jones, 2nd Vice-President, F. D. Mensing, Treasurer, and Council members D. S. Boyden, R. H. Carpenter, J. D. Cassell, E. H. Gurney, L. A. Harding, F. C. McIntosh, W. A. Rowe, Roswell Farnham and A. V. Hutchinson, Secretary.

Philadelphia Engineers Discuss Railway Air Conditioning

At a meeting of the Engineers Club of Philadelphia on November 17 over 100 members were in attendance to hear two illustrated talks on the Application of Air Conditioning to Railway Equipment.

Thornton Lewis, Executive Vice-President of the Carrier Corp., spoke on the Economics of Air Conditioning, tracing its development from processing to public building work and recently, its application to railway equipment .

D. E. French, Executive Vice-President of the Carrier Research Corp., was introduced and outlined to the members present a new development in air conditioning for railroad trains. He explained the three important requirements for an effective railway air cooling equipment and then described research work that had been carried on to provide a system using steam from the locomotive as the means of power for cooling.

There was much interest and discussion by the members in attendance, many of whom were Philadelphia Chapter Members of the A. S. H. V. E.

Employment Survey

THE Employment Survey undertaken by the Society has brought some favorable responses and it has now been expanded to reach 2,500 concerns. Of the first 1,500 inquiries sent out, 20 leads have been obtained so far and have been referred to men whose applications are on file.

Each local chapter of the Society has been requested to designate an Employment Representative, who will list men needing positions in his district, and the list of available positions will be referred from the Headquarters Office of the Society in order that the right man may be secured by those who need engineering service.

The men now serving the chapters are:

Illinois—A. G. Sutcliffe.
Massachusetts—Leslie Clough.
Michigan—G. H. Giguere.
New York—G. B. Nichols.
Philadelphia—Harry G. Black.
Pittsburgh—J. L. Blackshaw.
Western New York—J. J. Yager.
Wisconsin—Howard F. Haupt.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Membership Committee as soon as possible.

When the Membership Committee has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 8 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some members by December 15, 1931, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
ARNOLD, EDWARD YOUNG, Secretary-Manager, Heating and Piping Contractors St. Paul Assn., St. Paul, Minn.	Albert Buenger E. F. Jones	D. M. Forfar C. E. Gausman
CHRISTENSON, HARRY, Heating Superintendent, Hunter Prell Co., Battle Creek, Mich.	J. C. Matchett O. D. Marshall	W. W. Bradfield D. L. Taze
DOWNS, SEWELL HENRY, Chief Engineer, Clarage Fan Co., Kalamazoo, Mich.	D. L. Taze C. R. McConner	O. D. Marshall W. J. Temple
HULL, HARRY BLAIR, Frigidaire Corp., Dayton, Ohio.	F. J. Hoersting H. M. Williams, *A.C.S.*	G. A. Buvington, *A. S. M. E.* H. F. Smith, *A. S. M. E.*
MCDONALD, THOMAS, Canadian Manager, Minneapolis-Honeywell Regulator Co., Toronto, Ont., Canada.	W. R. Blackhall R. J. Millar	H. S. Moore M. W. Shears
NIGHTINGALE, GEORGE FREDERICK, Contract Sales Mgr., Hart & Cooley Mfg. Co., Chicago, Ill.	E. V. Hill P. J. Marschall	C. W. DeLand John Howatt
REID, HENRY P., Universal Atlas Cement Co., Chicago, Ill. (*Advancement*)	John Howatt	
TUCKERMAN, GEORGE EDGERTON, Manager, Air Conditioning Div., York Ice Machinery Corp., Philadelphia, Pa.	S. E. Plewes B. W. Wilson	R. C. Clarkson, Jr. E. A. Dambly

Candidates Elected

In the past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Membership Committee and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. II, Sec. VIII, of the By-Laws, the following list of candidates elected:

MEMBERS

CHASE, CHAUNCEY L., Gibbs & Hill, New York, N. Y.

GROSS, LYMAN CHARLES, Chief Mech. Engr., Magney & Tusler, Inc., Minneapolis, Minn.

KNEE, J. STUART, President, Knee Heating Co., Grand Rapids, Mich.

MORTON, HAROLD SYLVANUS, Chief Engr. and Genl. Mgr., Stott Stoker Co., St. Paul, Minn.

VAN ALSBURG, JEROLD HENRY, Hart & Cooley Mfg. Co., Holland, Mich.

ASSOCIATES

WIERENGA, PETER O., Vice-Pres. and Supt., Cox James Co., Grand Rapids, Mich.

ZIESSE, KARL L., Secy. and Treas., Phoenix Sprinkler & Heating Co., Grand Rapids, Mich.

JUNIOR

MEISEL, CARL L., Mech. Engr., 245 West 107th St., New York, N. Y.

Heating · Piping and Air Conditioning
EDITORIALS

A Conference on Cost-Cutting

A few days ago, we had the pleasure of inspecting a large industrial plant with the chief engineer of another plant. "I can tell pretty well whether the plant is operating efficiently or not by an inspection of the piping," he said. "In many cases it is neglected. Too often, maintenance of the piping is not regarded as highly important.

"Notice this leak. The piping does not have enough flexibility—too rigid. But see—the expansion joints are properly placed, but I'll bet they're not taken care of; look at this one. Dirt and grit have accumulated and worked into the sliding parts, causing it to stick. This joint does not look as though it ever was lubricated. The packing is hard and should be renewed. See—the steam is leaking out around the packing now.

"Something wrong here with the insulation. There has been a leak and it has been saturated with moisture. They should have stopped the drip or put waterproofing on the insulation; preferably both.

"What is the matter here? The insulation is broken and part of it on the floor. Someone thought it was necessary to step on the pipe to reach that valve up there and broke the insulation—bad practice. That insulation should be repaired at once. I would have a steel jacket put on the piping at that point."

And so it went; leaks and losses at many points. "And yet," said my companion, "They are having a conference in that office now on how to cut expenses."

The Economical Ounce

Steam traps are installed to remove condensate and prevent loss of live steam. The failure of a trap to perform either function may pass unnoticed, with consequent loss of steam or possible damage to equipment. Hence, all steam traps should be inspected periodically and in many large plants, trap inspection is a part of daily routine.

No check of steam trap performance can be considered complete unless the inspector is able to observe the operation of the trap. This means that a test valve should be provided on the discharge side of the trap (as near the trap as possible) and an additional valve should be provided to shut off the return line and prevent back pressure from blowing through the test valve.

A continuous discharge of steam from the test valve accompanied by very little water indicates that the trap is blowing live steam. This may be caused by a defect in the trap itself or by some temporary operating condition, such as a piece of scale lodged between the valve and the seat which would prevent the valve from closing. By shutting the line to the trap, enough condensate will quickly accumulate to prime the trap. If, after reopening the line to the trap, the trap operates in the normal manner, nothing further need be done but if the trap loses its prime, an inspection of the trap is necessary and defective parts should be replaced or the valve and seat relapped to insure a steam tight joint.

Inspection may reveal that a steam trap is discharging continuously. This may be due to foaming or priming boilers or perhaps the trap is too small for the job. The continuous discharge of condensate from the trap will be accompanied by flash steam, but an experienced man will have no difficulty in differentiating between a trap that is blowing condensate and one that is blowing live steam.

If inspection shows that a trap is not discharging at all, further investigation can be greatly simplified by first feeling the trap. If the trap is hot, it follows that steam is getting to the trap and its failure to open is due to no condensate coming. This may be caused by a leaky by-pass valve installed below the trap or to short circuiting, allowing condensate to back up in coils or steam heated machines.

On the other hand, if the trap is cold the pressure may be too high or the trap may be air-bound. If, after opening the pet-cock to relieve the air, the trap operates as it should—it is obvious that air-binding was the cause of the trouble and the pet-cock should be left cracked to prevent further trouble although, of course, some steam will be lost continuously.

If a trap is provided with a by-pass, the by-pass should also be tested at regular intervals. This can be done by closing the valves on the inlet to and discharge from the trap and then opening the test valve.

A continuous blow of steam through the test valve indicates a leaky by-pass valve that should be attended to immediately.

In addition to frequent inspection to determine the operation of steam traps, they should be systematically cleaned and carefully examined for mechanical trouble at least once a year. Satisfactory trap operation is possible with trap mechanisms that require new parts but if replacement is deferred too long, a complete mechanism may be necessary. The "ounce of prevention" will be more economical than the expensive "pound of cure."

The Wonders of Compound Interest

We like to pause in front of bank windows and study the tables which bankers so often display showing how much saving small weekly sums amounts to—at compound interest—at the end of five years, ten years, fifteen years, etc. It is pleasing to think that if we'd started saving a dollar a week five years ago, our Christmas shopping would be no problem. It is surprising the manner in which a small, regular sum of money soon totals a considerable sum.

It is no less surprising the manner in which a small waste soon amounts to a staggering total. When equipment is operated inefficiently and does not have the proper maintenance care, the daily losses will often be found way out of proportion to the cost of putting the equipment in proper shape, or to the cost of replacing it with modern equipment better suited to present day needs. Neglect to invest in adequate maintenance and replacements is probably one of our most wasteful practices.

"Open for Discussion"

Trunk Ducts for Warm Air Heating Systems Discussed

By James J. Finan*

IN THE second paragraph of the paper[1] on trunk ducts for fan blast systems of warm air heating the author states that duct openings for warm air risers leave only the top of the duct or tunnel; this is true. The author states it would be practically impossible to design ducts so exactly that volume dampers will not be necessary; I do not agree with him in this statement. In the far past some one decided that unless duct size to the classroom was 18 in. x 20 in. it would not be possible to get sufficient air into the classroom to provide heat as well as ventilation. With high speed blowers or fans the better design of ducts permits high air velocities so the size of the ventilating equipment may often be reduced over fifty per cent as to space occupied; high efficiencies can be obtained at a low cost of installation and operation.

As to the joining of trunks together so that the excess of one blower may be used to equalize the deficiency in delivery from another, I consider this poor policy except when connected up as an emergency to be used in case of the failure of one of the blowers. With the connection mentioned by the author in daily use, an unbalanced condition will arise, changing the air supply

* Supervising Engineer, Board of Education, City of Chicago.

1 "Trunk Ducts for the Fan Blast System of Warm Air Heating," by Platte Overton, HEATING, PIPING AND AIR CONDITIONING, November, 1930. Page 923.

to all the rooms unless a test had been conducted with blowers in operation at the same time when two or more blowers are found necessary. I believe in having these blowers supply a given zone, as different static pressures may be required in different parts of the building, and it is rarely found by test, after the apparatus has been installed, that two blowers of the same capacity and the same size will give the same static pressure reading at the same speed.

Referring to the paragraph "Temperature Regulation," illustrated as Fig. 1, in my judgment, the statement that a mixing damper thermostatically controlled will cause the tempered and warm air to equalize air on pressures is in error when applied to heating systems. Who has seen the thermostat that will keep mixing dampers floating through the air? The type of duct shown in Fig. 1 is not only costly but insanitary, being without sufficient head room to permit proper cleaning —which always should be done daily with water under pressure, (sweeping should never be allowed).

As to taking tempered air at or near the floor line of the duct or heat tunnel, in the writer's opinion this is not advisable and does not work out in our school buildings, stratifying of air being the cause of complaints from occupants of the classrooms. Heating and ventilating engineers are putting forth their best efforts to break up stratification of air in classrooms where pupils are sitting quietly for hours at a time, giving them a sufficient supply of air cleaned and properly humidified and warmed to the temperature required.

Concerning heat losses in concrete ducts, my opinion is that there is considerable loss to the earth or unoccupied spaces adjacent to the tunnel. Unless these spaces are used, any radiation through these walls is a loss.

All of the concrete ducts installed in the Chicago public school system have electric lights. Most connections for air washing have floor drains of a type without any direct sewer connections. Steam mains and water supply pipes should not be run in these plenum ducts owing to noises caused by flow of steam or air. Pipes also in many cases cause turbulence in the air, breaking up the direct flow through the re-heaters. All soil pipes, even though there are no joints in them, should be left out of plenum ducts for the same reason as well as for sanitary reasons in case of failure on any part of the sewer line which might cause fouling of the ventilating system.

Friction losses cause most of our troubles and at times make us wonder how we can get air into certain rooms. In my opinion, design velocities are at present calculated on too low a basis, resulting in increased costs for duct sizes that are really unnecessary.

Referring to Fig. 5 of the paper, in my opinion the type of individual duct system illustrated is one to be avoided, it not being possible to clean out these ducts. I had experience in one case in the Chicago schools when one of our buildings was being remodeled and the heating system of the type illustrated had been in use for about 35 years without air cleaning equipment. When the ducts were removed they were packed or partly filled with filth along the bottom of the ducts from 3 to 10 inches in depth.

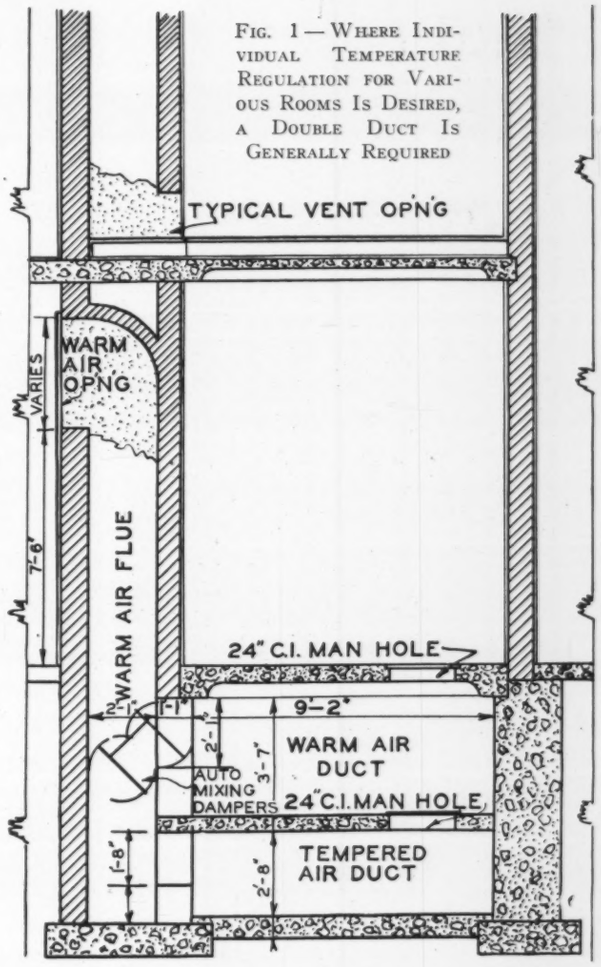

FIG. 1 — WHERE INDIVIDUAL TEMPERATURE REGULATION FOR VARIOUS ROOMS IS DESIRED, A DOUBLE DUCT IS GENERALLY REQUIRED

Fig. 5 also illustrates toilets, showers and lunchrooms supplied from the same plenum chamber as classrooms. This is a poor policy unless the exit ducts from these rooms are collected into one trunk duct equipped with an exhauster type of fan, as the air reverses itself when the main fan or blower is not in operation and in most cases back drafts in the supply ducts to these rooms carry odors from these rooms into the classrooms and other rooms of the building.

I want to state that I know the author personally and have the highest regard for him so any criticisms I make are without any disrespect whatever to him or to the paper, but merely express my opinion.

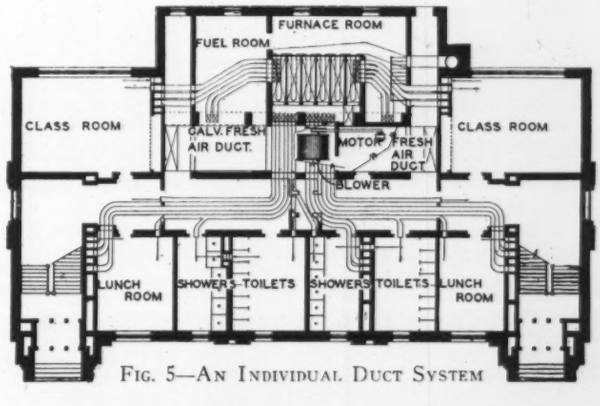

FIG. 5—AN INDIVIDUAL DUCT SYSTEM

Practical Piping Problems

Use of Check Valves in Industrial Piping Systems

W. H. Wilson's Monthly Discussion of the Problems He Meets From Day-to-Day

Check valves are useful in many ways and can be utilized to advantage in connection with much of the piping in an industrial plant.

—On Pump Discharge Piping

Fig. 1 shows the suction and discharge piping of two motor-driven centrifugal pumps installed in a pit below the floor line and used for pumping water at a low pressure. The suction is taken from a tank slightly higher than the pumps. No foot valve is on the suction pipes. The pumps are operated alternately, one being kept in reserve.

The electrical starting equipment is placed above the floor, in order that the pumps can be operated and controlled without entering the pit. The discharge piping leading from the pumps was installed without check valves.

When changing from one pump to the other, water from the discharge of the pump that was in operation would flow back through the discharge of the pump that had been shut down, moving its impeller in the reverse direction and rotating the pump motor; the water

flowed back to the suction tank. This caused a loss in pressure in the main discharge line.

With this arrangement of piping it was necessary to go into the pit and close the valve on the discharge of the pump that was not in operation. The installation of the check valves, shown at *A*, removed the necessity of entering the pit and closing this valve.

The installation of check valves on pump discharge lines for the higher pressure heads should be given especial consideration, especially when the valves are of the larger sizes. Check valves of some types may close too quickly, causing water hammer as well as giving trouble with the gate or disc. In such cases, it is often advisable to use a valve equipped with a cylinder and piston or other means that will cushion the disc, allowing it to seat slowly.

—On Paint Spraying Equipment

Fig. 2 shows a storage tank and the piping used for spraying the interior of a building with a lime wash.

The lime wash, or cold water paint, was put in the tank and the compressed air supply entered at the valve *D*. With the air passing through the nozzle in the tee below the tank and air pressure from the equalizing connection *C*, the liquid was drawn and forced from the tank, the spray being controlled by the valve *B*.

In one instance, the operator, on leaving his work for a short period, closed the valve *B* at the spray nozzle and for some reason, not explained, the valve *C* was also closed and valve *D* left open. During this time the plant air compressor was suddenly shut down. The demand for air in other departments caused a rapid reduction in the main pressure. The air pressure in the upper part of the tank foced the liquid down and back through the air supply pipe into the shop lines. The lime deposit hardened in the pipes, and was difficult to remove. A check valve installed at *E* would have prevented this.

—On a Hoist

Fig. 3 shows a hoist of the cylinder type in which compressed air is used for raising the load. As a safety feature a suitable check valve should be used on the air supply pipe. This can be a swing check valve as shown at *F* or a vertical check valve as shown at *G*. The air exhaust pipe is shown at *H*.

In case of interruption of the air pressure, when the hoist is not equipped with a check valve and the operating valve is not in the neutral position, the pressure under the piston in the hoist will flow back through the open supply line, the load will descend rapidly and perhaps cause injury.

A check valve on the air supply pipe to hoists of this type will retain the pressure and prevent a back flow of air from the hoist.

—On Brake Testing Lines

A check valve should always be provided on the hose connection used for testing the air brake equipment of railway cars. A sudden reduction of supply line pressure, accidental or otherwise, will cause the brakes on the car to be applied automatically, endangering workmen who may be under the car. A check valve on the air test hose will prevent a back flow of the air and a reduction in the train line pressure.

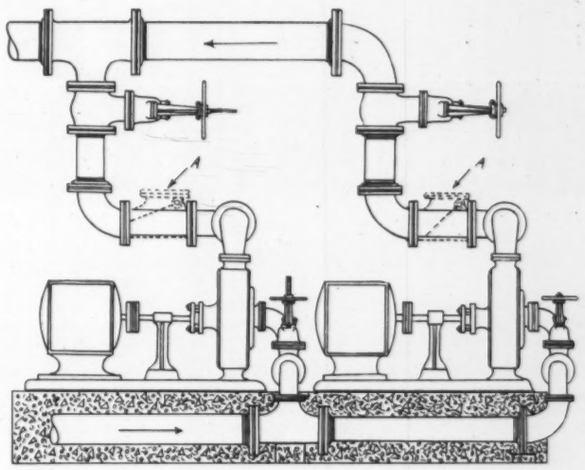

FIG. 1—SUCTION AND DISCHARGE PIPING FOR TWO CENTRIFUGAL PUMPS. THE CHECK VALVES ARE SHOWN AT *A*

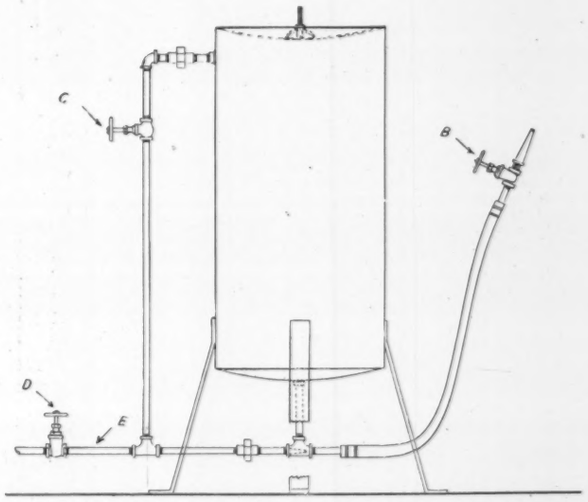

FIG. 2—EQUIPMENT FOR SPRAYING PAINT, USING AIR PRESSURE. A CHECK VALVE SHOULD BE INSTALLED AT *E*

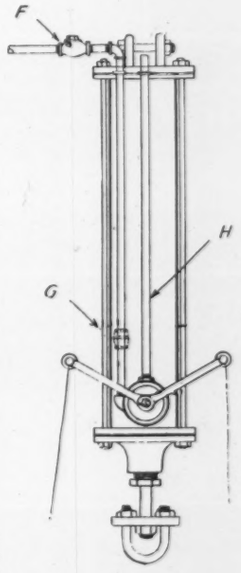

FIG. 3—A HOIST IN WHICH COMPRESSED AIR IS USED FOR RAISING THE LOAD. A SWING CHECK VALVE AS SHOWN AT *F* OR A VERTICAL CHECK VALVE AS SHOWN AT *G* SHOULD BE USED

Conventions and Expositions

Welding Conference: Annual conference to be held by engineering extension department, Purdue University, Lafayette, Ind., Dec. 10-11. In charge, Prof. W. A. Knapp, Purdue University, Lafayette, Ind.

Society of Rheology: Annual meeting, Dec. 28-30; Rochester, New York. Chairman of Program Committee, Eugene C. Bingham, Gayley Chemical Laboratory, Lafayette College, Easton, Pa.

American Society of Heating and Ventilating Engineers: Annual meeting, Jan. 25-29; Cleveland, Ohio. (Joint meeting with A. S. R. E.) Secretary, A. V. Hutchinson, 51 Madison ave., New York City.

American Society of Refrigerating Engineers: Annual convention, Jan. 26-29 (Joint meeting with A. S. H. V. E.); Hotel Cleveland, Cleveland, Ohio. Secretary, David L. Fiske, 37 W. 39th St., New York City.

International Heating and Ventilating Exposition: Jan. 25-29; Cleveland Auditorium, Cleveland, Ohio. Manager, Charles F. Roth, International Exposition Co., Grand Central Palace, New York City.

Recent Trade Literature

Concealed Radiators: C. A. Dunham Co., 450 E. Ohio st., Chicago, Ill.; 32-page bulletin presenting complete descriptions, engineering information, dimensions, methods of installation, piping details, etc., for concealed radiators. An adjustable regulating fitting which governs the flow of steam to every radiator is described.

Couplings: Crocker-Wheeler Manufacturing Company, Ampere, N. J.; four-page bulletin describing the construction of and giving dimensions for resilient flexible couplings for maximum r.p.m.'s ranging from 10,000 to 1,800 and horsepower per 100 r.p.m. from ⅛ to 35.

Dust Collecting: The Dust Recovering & Conveying Co., Harvard ave. and E. 116th st., Cleveland, Ohio; four-page bulletin discussing waste product reclamation and describing the installation of bag filters in a typical plant where ten tons of dust per day are recovered.

Electrical Recording Instruments: General Electric Company, Schenectady, N. Y.; 20-page data book containing descriptions and list prices of switchboard voltmeters, ammeters, wattmeters, reactive-volt-ampere meters, frequency meters and power factor meters; and portable voltmeters, millivoltmeters, ammeters, wattmeters, power factor meters, shunts, and current transformers—for alternating and direct current.

Grilles: Uni-flow Grille Products Co., 2265 W. Grand blvd., Detroit, Mich.; 12-page data book containing dimensions, installation diagrams, description of construction, reports of tests, etc., for fin and bar type grilles for use with forced air heating, air conditioning, concealed radiation, cooling units, humidifiers, cabinets, etc.

Heat Controls: Eastman Heat Control Corporation, 1 State st., Boston, Mass.; four-page folder describing a device applicable to all classes of steam heating plants, causing them to operate on pressures of from six to eight ounces. A list of typical installations and savings made is included.

Meters: Builders Iron Foundry, Providence, Rhode Island; four-page bulletin illustrating and describing electrically operated recording and indicating flow meters for steam, air, gas, water, oil and other lines, including a discussion of the advantages of proper metering.

Motors: Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.; data sheet on single phase motors, 2 to 7½ hp., repulsion—induction, constant speed, 110 and 220 volts. Because of torque characteristics, these motors are applicable to pumps, compressors, ventilating fans, blowers, etc.

Radiator Valves: The Powers Regulator Company, 2720 Greenview ave., Chicago, Ill.; eight-page bulletin describing the operation and construction of self-operating thermostatic radiator valves for controlling direct, indirect, and concealed radiation and unit heaters. Photographs and diagrams of typical installations are included as are dimensions and list prices.

Steam Purifiers and Oil Separators: Schutte & Koerting Company, Philadelphia, Pa.; eight-page bulletin describing operation, installation, and giving dimensions of, internal and external steam purifiers and adhesion separators for removing oil from exhaust steam.

Stoker Drives: Combustion Engineering Corporation, 200 Madison ave., New York City; four-page bulletin containing a description of the operation of an electric drive for underfeed stokers; variation of the coal feed is accomplished by varying the number of strokes (of uniform length and constant speed) per minute.

Traps: Armstrong Machine Works, Three Rivers, Mich.; 12-page house organ containing an article on trapping unit heaters, describing a new compound trap, etc.

Unit Heaters: Niagara Blower Company, 6 E. 45th st., New York City; four-page pamphlet giving rated output capacities, dimensions, and describing features of suspended disc fan heaters of all aluminum welded construction and heaters with a copper heating surface.

Unit Heaters: The Stanwood Corporation, Cincinnati, Ohio; four-page folder giving specifications, dimensions and general information for gas-fired unit heaters of 166,000, 249,000 and 415,000 Btu outputs; for heating factories, hangars, garages, warehouses, etc.

Valves: Everlasting Valve Company, 1 Montgomery st., Jersey City, N. J.; four-page bulletin giving descriptions, dimensions, price list, etc., for low pressure (60 lb. maximum) outside packed valves for acids, alkalies, caustic, cellulose, coal tar, emulsions, syrups, viscose, etc.

Welding Fittings: Tube-Turns, Inc., 1303 S. Shelby st., Louisville, Ky.; data card giving dimensions and describing features of seamless 90-degree elbows for pipe welding formed on a radius of one time the nominal pipe size. Available in standard thickness, iron pipe sizes, in diameters from 2 to 12 in.

X-ray Examination: Combustion Engineering Corporation, 200 Madison ave., New York City; eight-page reprint discussing the x-ray method of testing welded pressure vessel seams as prescribed in the A. S. M. E. code for welded boiler drums, and describing a representative installation of x-ray equipment.

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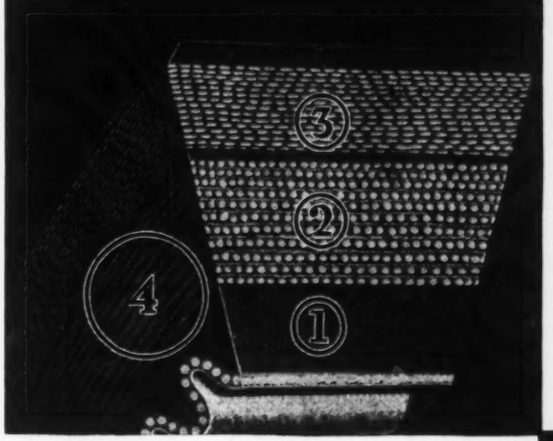

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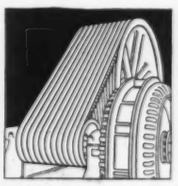

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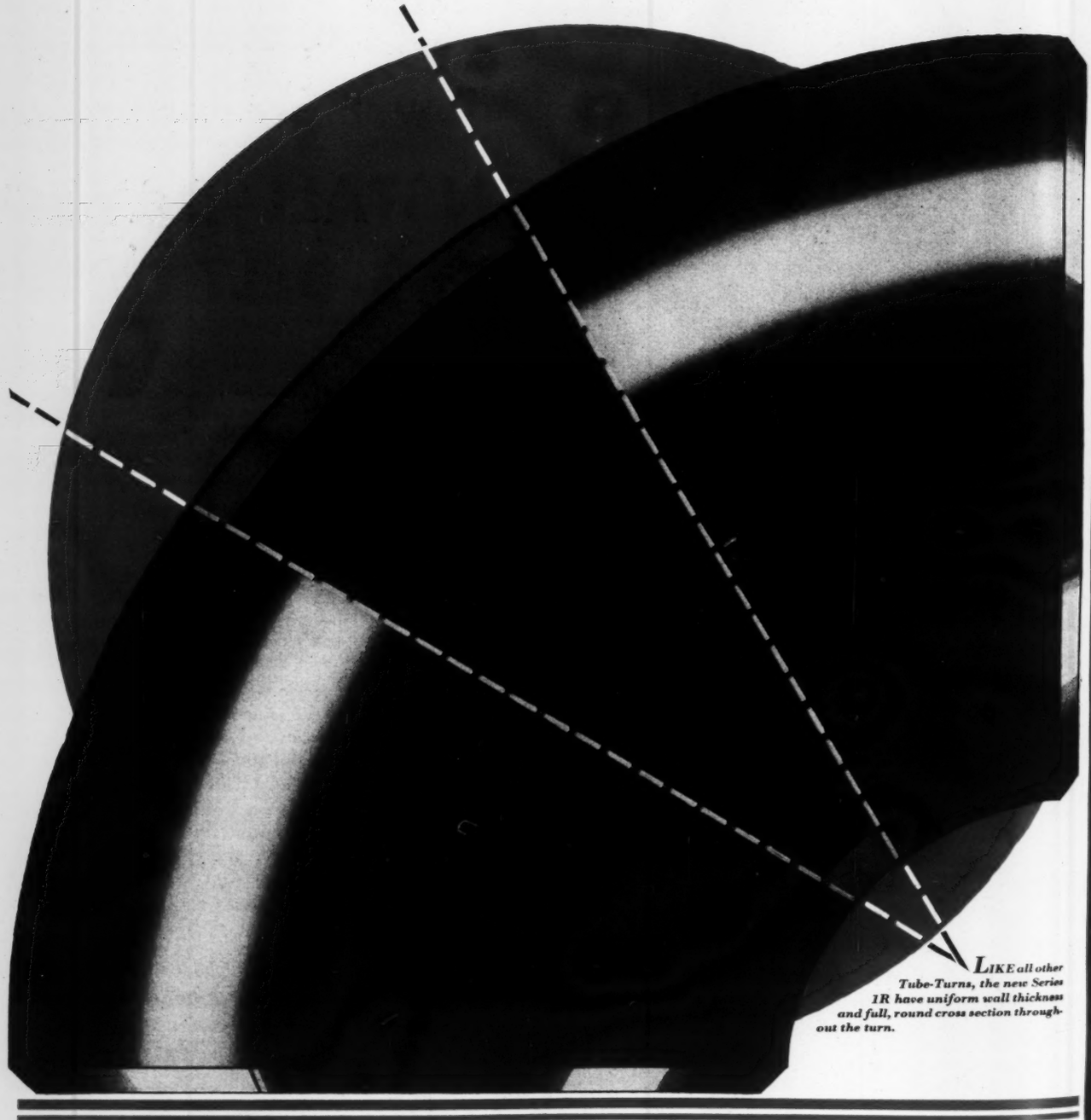

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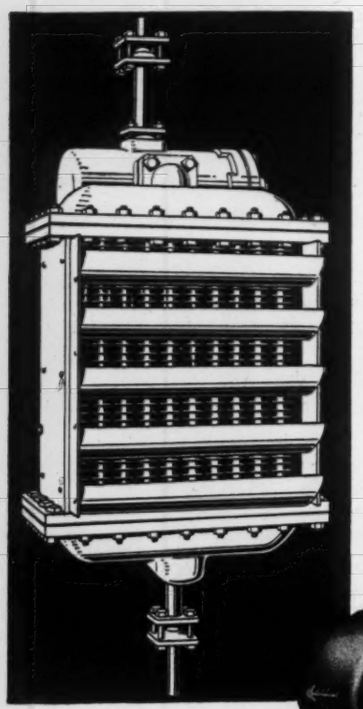

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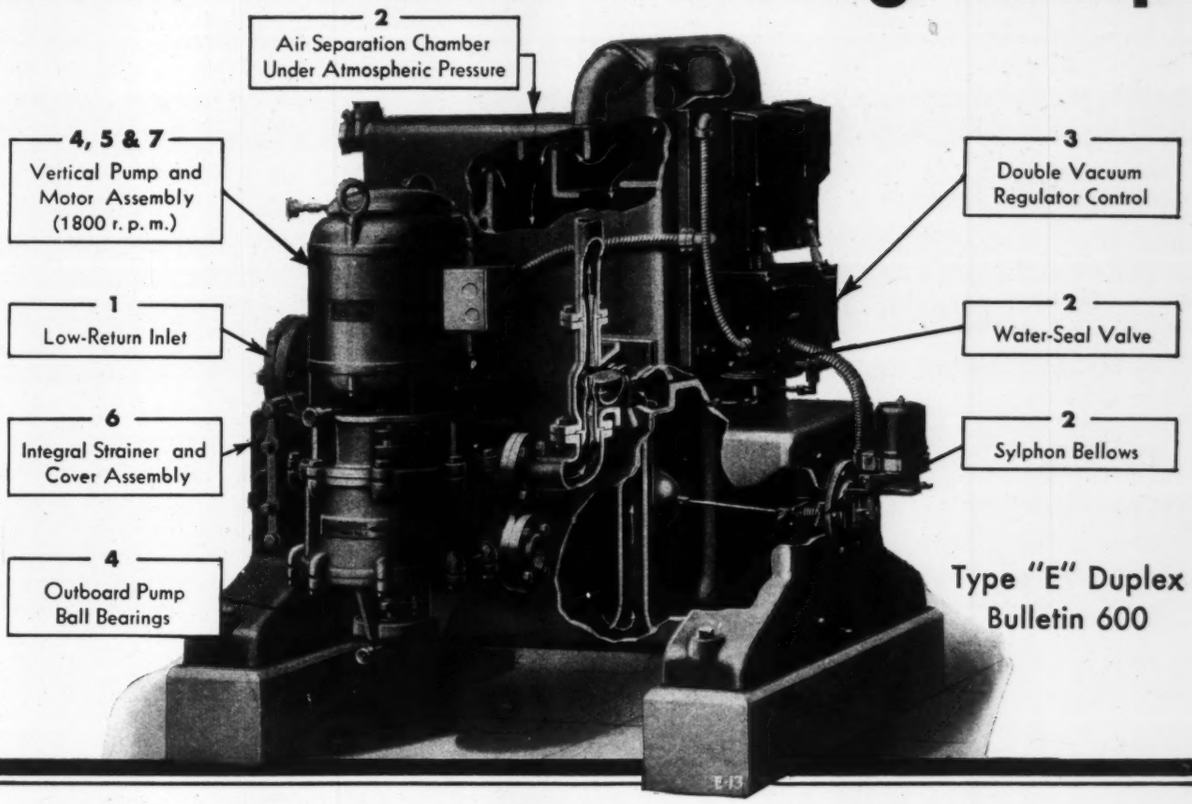

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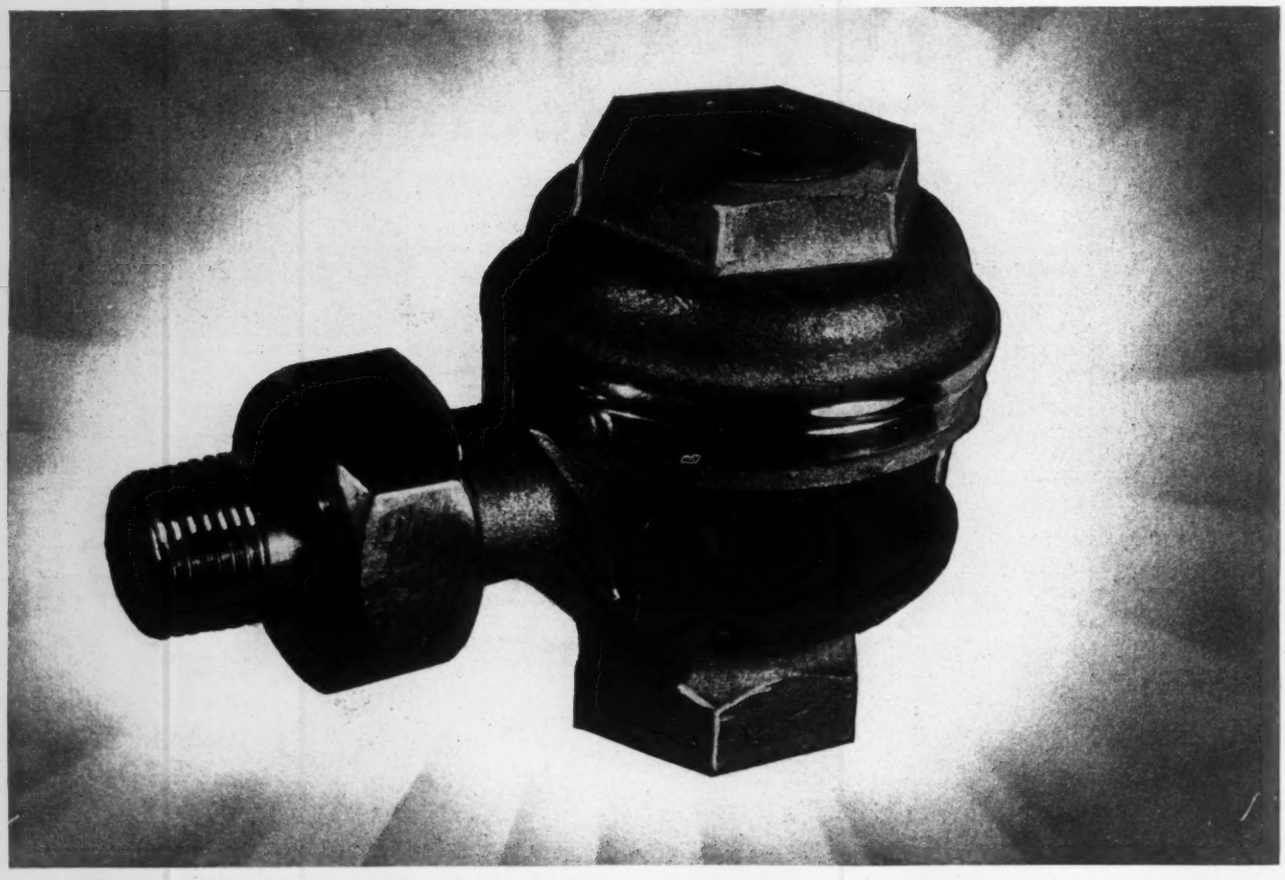

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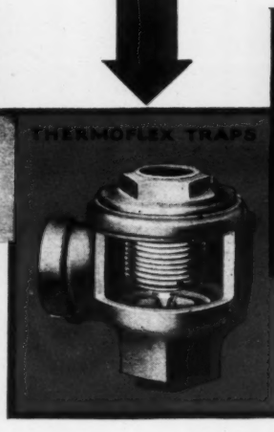

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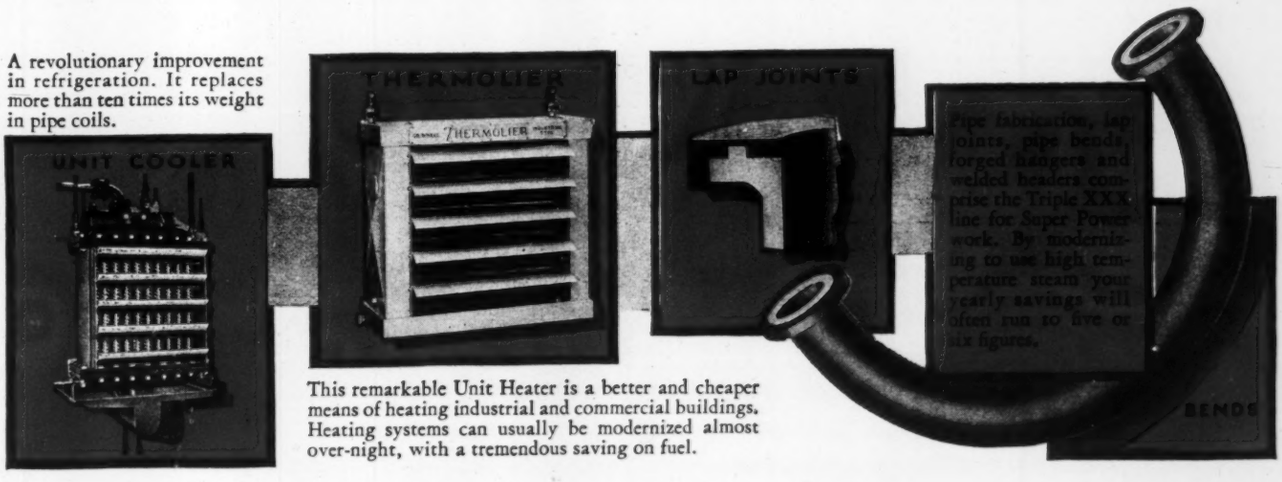

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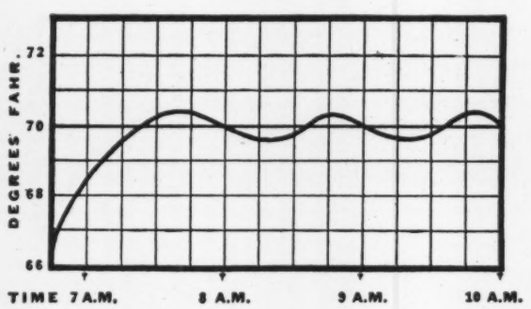

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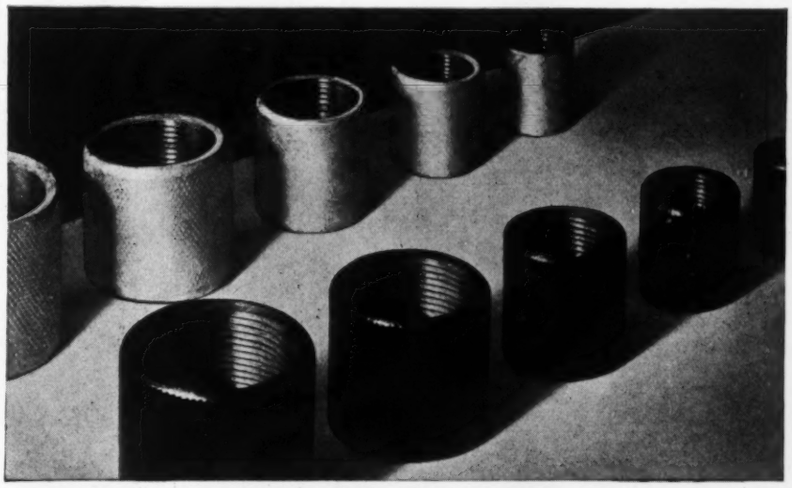
J&L STEEL PIPE IS MADE TO MEET CUSTOMER REQUIREMENTS

In the production of its steel pipe, J&L is unhampered by any consideration save the needs of its customers. Ownership-control over all raw materials and processes of manufacture from ore to finished products permits J&L to keep its products and its policies abreast of changing customer requirements. J&L steel pipe is produced with the properties that fit it to meet the needs of today. If tomorrow brings new needs, J&L pipe will be produced to meet them.



SOUND COUPLINGS

A coupling can be no better than the steel from which it is made. To assure that the steel for J&L couplings will conform to the high J&L standards and will have the exact properties desired, it is selected with scientific exactitude. The finishing of the coupling is also of great importance, and so is done with unusual care. Each J&L coupling is sized, and gauged for thread pitch, general contour, etc., before it is approved. The rewards of this extra care are found in the extra service J&L pipe installations give.

J&L STEEL

OUTSTANDING FEATURES OF J & L STEEL PIPE

1—Selected Steel
2—Free from Excess Scale
3—Accurate Mill Threads
4—Free Cutting—Easy to Thread
5—Sound Couplings
6—Thoroughly Coated
7—Rigidly Inspected
8—Galvanized Pipe Uniformly Coated—No Clogging with Spelter

JONES & LAUGHLIN STEEL CORPORATION

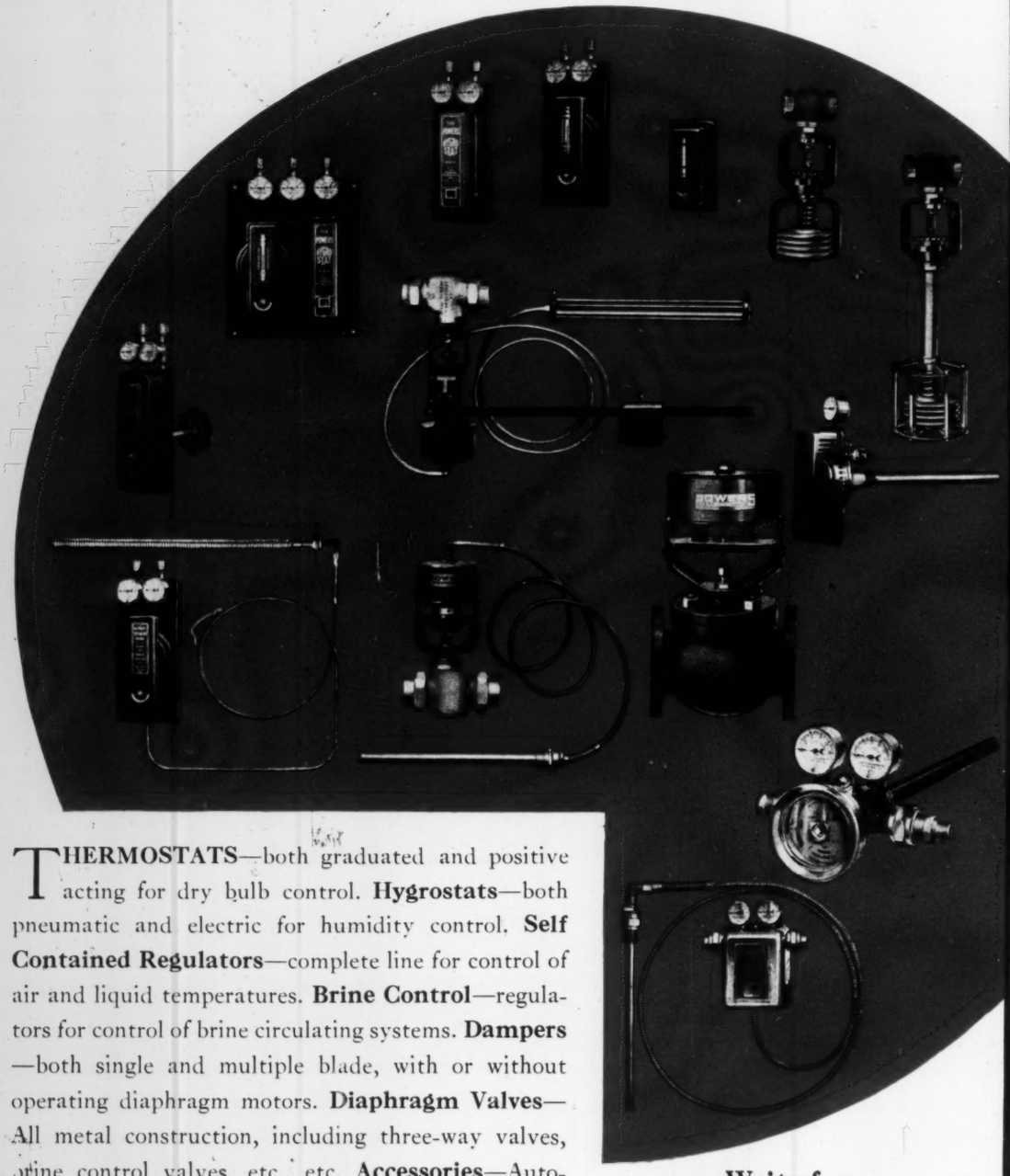
AMERICAN IRON AND STEEL WORKS
JONES & LAUGHLIN BUILDING, PITTSBURGH, PENNSYLVANIA

Sales Offices: Atlanta, Boston, Buffalo, Chicago, Cincinnati, Cleveland, Dallas, Denver, Detroit, Erie, Los Angeles, Memphis, Milwaukee, Minneapolis, New York, Philadelphia, Pittsburgh, St. Louis, San Francisco
Warehouses: CHICAGO, CINCINNATI, DETROIT, MEMPHIS, NEW ORLEANS, PITTSBURGH

J&L JUNIOR BEAMS | J&L STEEL PIPE | J&L LIGHT CHANNELS | J&L NAILS and STAPLES BRIGHT and GALVANIZED | J&L CONCRETE BARS | J&L STRUCTURAL STEEL | J&L STEEL PILING

ACCURATE DEPENDABLE CONTROL *for Air Conditioning*

POWERS



THERMOSTATS—both graduated and positive acting for dry bulb control. **Hygrostats**—both pneumatic and electric for humidity control. **Self Contained Regulators**—complete line for control of air and liquid temperatures. **Brine Control**—regulators for control of brine circulating systems. **Dampers**—both single and multiple blade, with or without operating diaphragm motors. **Diaphragm Valves**—All metal construction, including three-way valves, brine control valves, etc., etc. **Accessories**—Automatic Water Pan for wet bulb control, Relays, Pressure Reducing Valves, Pneumatic Switches, Dial Thermometers, etc., etc.

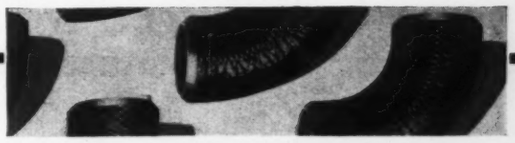
Write for Bulletin No. 251

which describes Instruments for Air Conditioning Equipment.

THE POWERS REGULATOR COMPANY

40 years of specialization in temperature control

Offices in 43 Cities—**Chicago, 2720 Greenview Ave.; New York, 231 E. 46th St.; Toronto, 106 Lombard St.**



HOLD THOSE SPECIFICATIONS!

Here's real news for Pipe Users...

SINCE welding fittings were first developed there has been a steadily increasing demand for such fittings made of genuine Reading *Puddled* Iron — the kind of wrought iron that has proved its value by generations of service.

Such welding fittings are now available—*for the first time.*

Now you can make a welded Reading Puddled Iron Pipe system of superior resistance to corrosion, at every point.

Now you can make piping systems of other metals *better* by using welding ells of this superior material at critical points.

Now you can be assured of longer life in piping systems, greater freedom from trouble *plus* the efficiency of welding fittings.

Made by MIDWEST *from Reading Puddled Iron*

These new fittings are made by the new patented process of the Midwest Piping & Supply Company, Inc., 1450 South Second Street, St. Louis Mo., from specially selected Reading *Puddled* iron skelp. You can get them in the sizes you need. They are identified by a special label and Reading knurl showing that they are made of genuine Reading *Puddled* Iron.

Ask Midwest for complete information about these fittings which give to welding ells all the time-tested resistance to fatigue, corrosion, and other pipe enemies that has always characterized genuine Reading *Puddled* Iron Pipe.

READING IRON COMPANY

General Offices: 401 N. Broad St., Philadelphia, Pa.
Mills: Reading, Pa.

Atlanta, Baltimore, Boston, Buffalo, Chicago, Cincinnati, Detroit, Houston, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco, Seattle, St. Louis, Tulsa

Reading Products: Pipe Tubing Casing Sucker Rods Nipples Couplings Bar Iron Blooms Cut Nails Boiler Tubes

ANOTHER MIDWEST DEVELOPMENT THAT

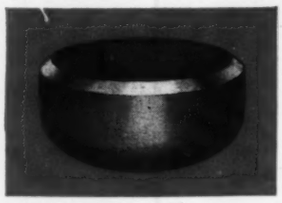
MIDWEST

Look for this knurl marking—it identifies Midwest Welding Ells that are made from genuine Reading Puddled Iron skelp. A special label also aids in identification.

★
READING PUDDLED IRON—the genuine wrought iron that has proved its resistance to corrosion by generations of outstanding service. It is identified by the copyrighted knurl mark of the Reading Iron Company.

THE GREATER MIDWEST PIPING SERVICE

HERE are other Midwest Welding Fittings that also help reduce the cost and improve the design of many types of piping systems. At present, these fittings are carried in stock made only from the same material as mild steel pipe. Complete data including dimensions and prices are given in Bulletin WF-2; write the nearest Midwest office for a copy.



MIDWEST WELDING HEAD

The ellipsoidal form reduces unit stress in the metal to a minimum. The long tangent puts the circumferential weld to the pipe entirely in tension—it is not subjected to shear and bending. Application is much easier and a neat appearing job is assured. Standard weight and extra heavy Heads carried in stock from 3″ to 24″.

FILLS AN IMPORTANT PIPING NEED

WELDING ELLS made from Reading ★ Puddled Iron

FOR the many jobs where genuine wrought iron pipe is advantageous—and where welding assures a better or cheaper installation than other methods of connecting pipe—Midwest now offers welding ells made from genuine Reading Puddled Iron skelp. At present, the sizes are from 2″ to 10″ inclusive; both standard weight and extra heavy are available.

Midwest ★Genuine Wrought Iron Welding Ells—like those made from mild steel pipe material—have a number of distinctive and important advantages. Prominent among these are *dimensional accuracy* and *uniformity*—the ells have full and true circular cross sections and are to exact radius. This results from a special *compression* sizing operation that is exclusive with Midwest. The manufacturing procedure also holds the wall thickness uniform and within very close tolerances; this thickness is never less than the nominal pipe wall thickness.

The included angle of every Midwest Welding Ell is exactly 90° or 45° and center-to-face dimensions are accurately maintained—because of ingenious fixtures used in machine-beveling the ends. Inspection is very rigid and each ell is subjected to a hydrostatic test pressure 25% greater than the mill test of the corresponding pipe.

Long tangents are another distinctive advantage—the pipe and fitting can be lined up more quickly and accurately. One quarter inch of tangent is provided for each inch of fitting diameter; thus an 8-inch ell has tangents 2 inches long. Particularly in the larger sizes, an appreciable saving results from the decreased length of pipe required.

Each Midwest Welding Ell is made from one piece of Reading Puddled Iron skelp by a special process developed and patented by Midwest; there is one welded longitudinal seam along the inner circumference. The final working of the fitting is in *compression* at a forging heat, thus normalizing and refining the skelp and the weld—it is not extruded or stretched.

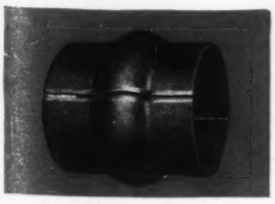
Since these Midwest Welding Ells are made from Reading Puddled Iron skelp, they have the same corrosion resistance, the same coefficient of expansion and the same welding characteristics as ★genuine wrought iron pipe.

Get in touch with the nearest Midwest office for complete information regarding Midwest ★Genuine Wrought Iron Welding Ells.

Midwest Piping & Supply Co., Inc.

Main Office: 1450 South Second St., St. Louis

Offices: Chicago, 208 South La Salle Street . . . Houston, 600 Bringhurst Street . . . Los Angeles, 520 Anderson Street . . . New York (Ballwood Division), 30 Church Street . . . Tulsa, 733 Mayo Building

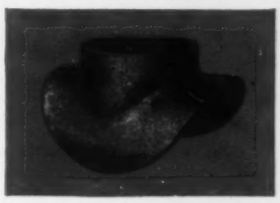


MIDWEST WELDING SLEEVE

Used to reinforce a butt line weld between two pieces of pipe, it relieves the butt weld of any bending stress and much of the tensile stress to which it would otherwise be subjected. Transverse recess in sleeve permits its application over the conventional butt line weld. Sleeves are carried in stock from 4″ to 24″.

MIDWEST WELDING SADDLE

It not only reinforces the junction of neck and body of a welded header, but also compensates for the weakening of header body that results from loss of the metal cut out for the neck opening. Tests proved this saddle materially increases the strength of a welded header over customary gusset plate construction. Made in sizes from 4″ x 2″ to 24″ x 24″.



TWO QUESTIONS

1 Why are leading pipe manufacturers offering pipe in all sizes with beveled ends for welding?

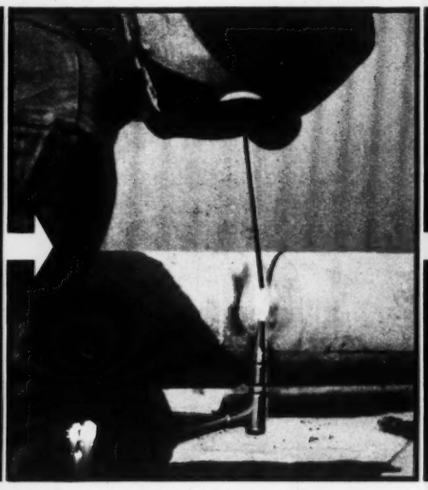
2 Why are established makers of pipe fittings now producing tees, elbows, flanges, and short- and long-radius turns for welding?

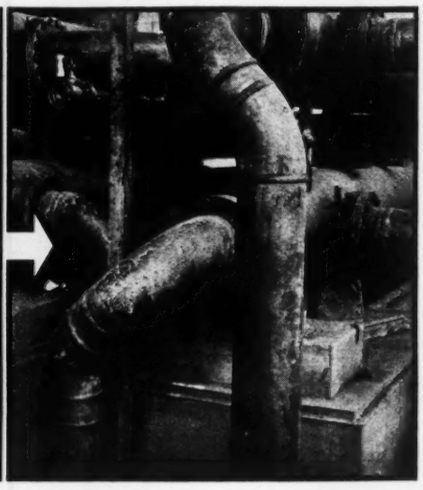
—AND AN ANSWER TO MANY OF YOUR PIPING PROBLEMS

THE ANSWER IS: Because oxy-acetylene welding is now accepted as an economical and dependable method of installing piping systems in office buildings, factories, churches, schools, hospitals, and private homes.

Architects and engineers are specifying oxwelded piping because welding eliminates the chief causes of leakage, friction, radiation losses, and insulation expense. Welded systems are more compact, lighter, stronger, and easier to design and construct. Their first cost is less, and maintenance is negligible.

If you feel that these inherent advantages of oxwelded systems merit further investigation, send today for "Oxwelded Construction for Modern Piping Services," "Design Standards for Oxwelded Steel and Wrought Iron Piping," and "Fabrication of Welded Piping Designs." These books are offered without charge or obligation to architects, specification writers, and engineers.





THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

126 Producing Plants UCC 627 Warehouse Stocks

IN CANADA, DOMINION OXYGEN COMPANY, LTD., TORONTO

District Offices

Atlanta	Detroit	New York
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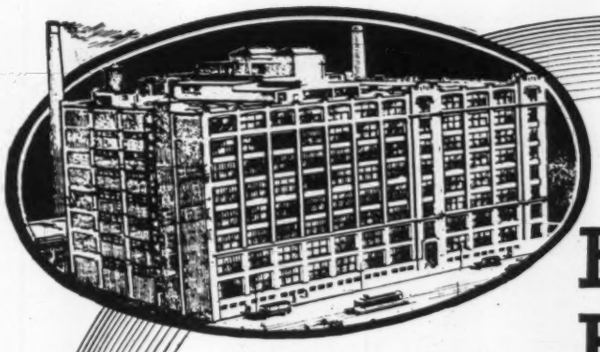
Cleveland	Milwaukee	Seattle
Denver	Minneapolis	Tulsa

LINDE OXYGEN . PREST-O-LITE ACETYLENE · OXWELD APPARATUS AND SUPPLIES · UNION CARBIDE



FACTORY HEATING

AS MODERN AS IN THE CHRYSLER BUILDING

Do you know that 20 to 50% of the steam used to heat factory buildings equipped with old time heating systems *could be saved? Do you know* that these stupendous savings can be made at a *trifling expense?*

The real difference between the most modern steam heating system and those still widely used in plants and factories of every description, is in the method of removing the water of condensation.

For maximum efficiency, every radiator, every pipe coil, every unit heater should be equipped with a separate Sarco Steam Trap. All air and water will then be removed promptly, but no steam will be allowed to escape.

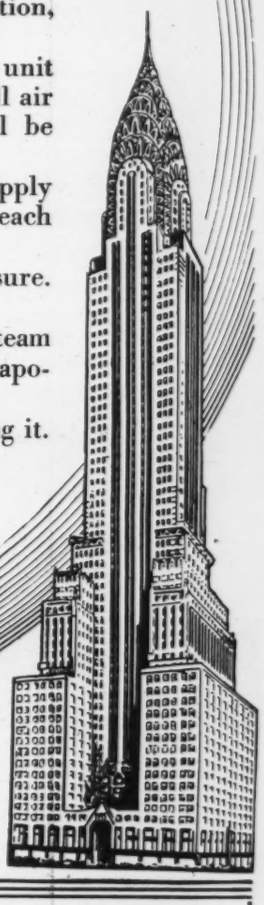
Water of condensation should also be removed from the supply mains and risers by the use of Sarco Traps, so that the steam can reach the heating coils as hot and dry as possible.

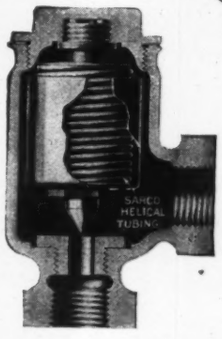
Sarco Traps are available in types for high or low steam pressure. They are inexpensive, easy to install, and require no attention.

They are used widely also for draining condensate from steam heated industrial equipment, such as jacketed kettles, dryers, evaporators, stills, retorts, hot water heaters, etc.

Catalog O-95 contains full information. The coupon will bring it.

SARCO COMPANY, INC.
183 Madison Avenue New York, N.Y.
BRANCHES IN PRINCIPAL CITIES
Sarco Canada Limited, Federal Bldg., Toronto, Ont.
Walker, Crosweller & Co., 20 Queen Elizabeth St., London S. E. 1





See our exhibit at Booth No. 150 at the International Heating & Ventilating Exposition, Cleveland, O., January 25th to 29th, inclusive.

SARCO STEAM TRAP

SARCO COMPANY, Inc., 183 Madison Ave., New York, N.Y.

☐ Send a Sarco Steam Trap on 30 days' free trial.
Size ..... for pressure ..... lbs.

☐ Send Steam Trap Booklet O-95.

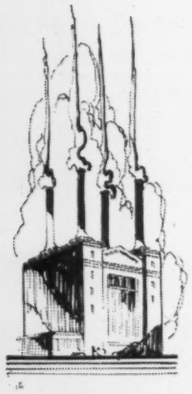
Name .....

Address .....

City ..... State .....

STAMINA

JUST as speed, a stout heart and stamina are the qualities that make a winning horse, so does super strength, uniformity and safety make "STANDARD" SEAMLESS a WINNING POWER PIPE among power plant engineers the country over.



SPANG, CHALFANT & CO., INC.
GENERAL OFFICES, CLARK BUILDING

Sales Offices: New York, Boston, Pittsburgh, Chicago, St. Louis, Tulsa, Los Angeles, Dallas, San Francisco
Welded Mills: Etna, Penna., Sharpsburg, Penna.
Seamless Mills: Ambridge, Penna.

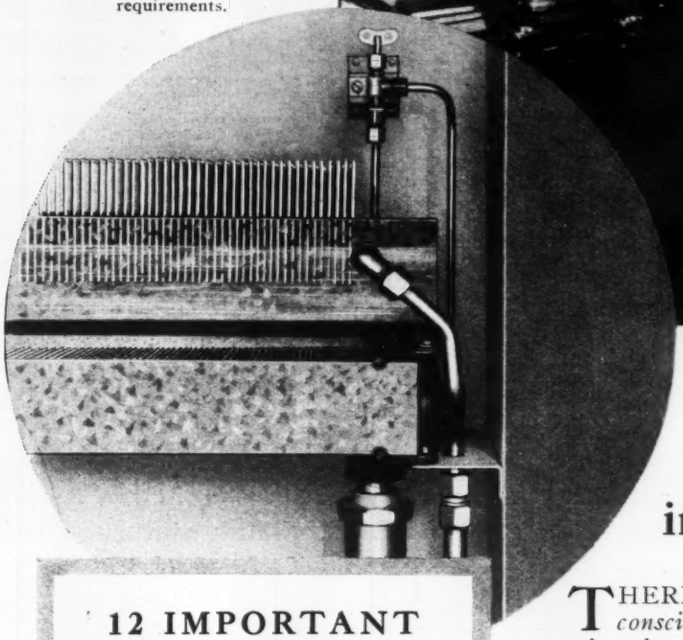
STANDARD
SEAMLESS
POWER PIPING

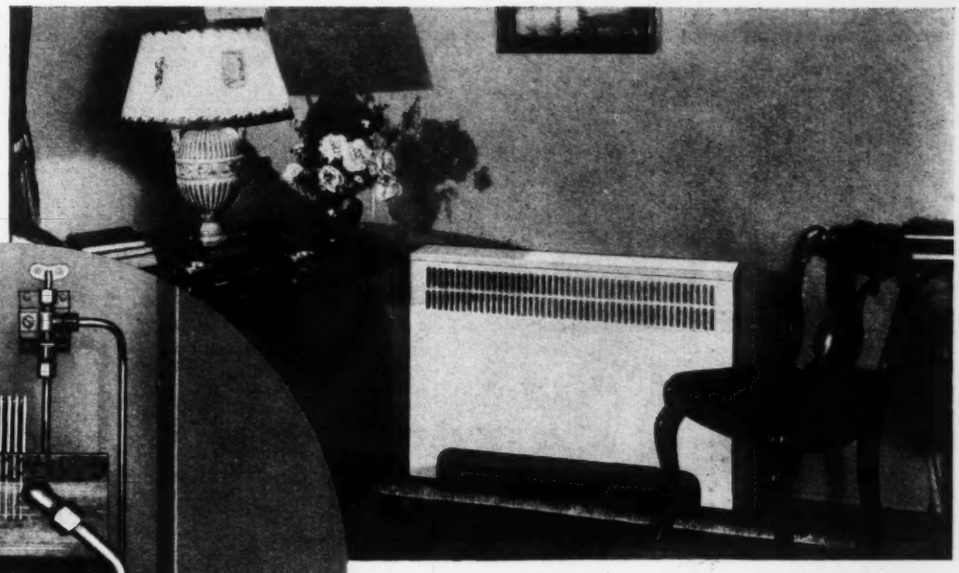
Announcing . . .

A NEW HUMIDIFIER

BY TRANE

The inside view of the Trane Humidifier shows the simplicity of construction. Water-absorbing fins transmit water from the tank to a position in the path of the heated air—humidified heat passes out of the grilles at the top. The easily accessible valve controls the supply of water to the tank and can be adjusted to meet humidification requirements.





Standard Humidifiers are attractively finished; colors available—gray, ivory, brown and tan, all giving two-tone effect, or gray primer coat only.

12 IMPORTANT ADVANTAGES

1. Low first cost.
2. Easy to install.
3. Simplicity of operation—no adjustments required.
4. Noiseless in operation.
5. Cleanliness. Removes dust from the air.
6. Moistens air to prevent colds and other winter ailments.
7. Low maintenance cost.
8. No float valves.
9. Saturated air — no beads of moisture to collect on walls.
10. Eliminates static discharges caused by dry rugs.
11. Rugs, wall paper and furniture last longer — no drying out.
12. Can be concealed in the wall or new installations. The humidifier assembly can be attached to practically any previous Trane Convection Heater installation.

Easily installed in any home or office

THERE is no doubt that the public has become "*humidity conscious*" in the past few years. Many makeshift devices have been offered to meet this widespread demand for properly humidified air. But most of the devices have either been wholly inadequate, too expensive, or too difficult to install. In presenting this new humidifier, Trane has overcome all these objections and has thereby made it *practicable* for any home or office heated by steam or hot water to enjoy properly humidified air.

The Trane Convection Humidifier is available in two sizes—one for installations of 15,000 cubic feet, which humidifies the air with from 7 to 10 gallons of water daily; and one for larger installations, which humidifies the air with 15 to 20 gallons daily. Humidity is by air absorption of water only. There are no sprays or jets to induce more vapor into the room than the air can contain.

Write for prices and complete details and be prepared to offer your clients the very latest in humidifying equipment. The Trane Company, Dept. 12, 212 Cameron Avenue, La Crosse, Wisconsin.

TRANE

Kennedy

A single source *for* ALL your valves

Standard Bronze Globe Valve

Radiator Valve

Bronze Check Valve

Kennedy Standard Bronze Gate Valve

Iron Body Gate Valve

KENNEDY Fittings, too

Complete lines of black and galvanized malleable iron screwed fittings, brass or bronze screwed fittings and standard cast iron flanged fittings and flanges are also included among the large list of Kennedy Products—an additional advantage of standardizing on Kennedy.

The Comment Corner

"Your fittings and valves are perfectly satisfactory. I highly recommend them to other users," writes a long-time user of Kennedy products—one of hundreds who have written us after standardizing on Kennedy.

WHETHER you need valves for water service lines, radiators, fire protection systems or steam control—any pressure, material or finish — there is a suitable Kennedy type and size.

Standardizing on Kennedy gives you a single—and *dependable*—source of supply for all your valve requirements—dependable in design, workmanship and service.

The men who operate Kennedy Valves know they can always be depended upon to close tightly, release promptly, and respond to every service demand. For half a century and in thousands of plants, Kennedy Valves of every type and size have been demonstrating these characteristics and establishing the Kennedy reputation for thorough reliability.

Specify Kennedys for your next job. Note their attractive appearance, clean-cut machine work, finish, and threading, and freedom from flaws of any kind. You will quickly see why so many contractors, engineers and architects have standardized on Kennedys for a quarter of a century and more, and keep on using them to assure profitable, trouble free piping jobs.

The Kennedy Valve Mfg. Co., Elmira, N. Y.

WAREHOUSES: New York, 128-132 White Street; Chicago, 1335-1337 S. Clinton Street; San Francisco, 448-450 Tenth Street

SALES OFFICES: New York, Philadelphia, Cleveland, Chicago, Atlanta, Salt Lake City, El Paso, Los Angeles, San Francisco, Seattle

KENNEDY

VALVES-PIPE FITTINGS-FIRE HYDRANTS

The Barber-Colman Electric System of Temperature Control

AN ACCURATE, GOOD-LOOKING THERMOSTAT

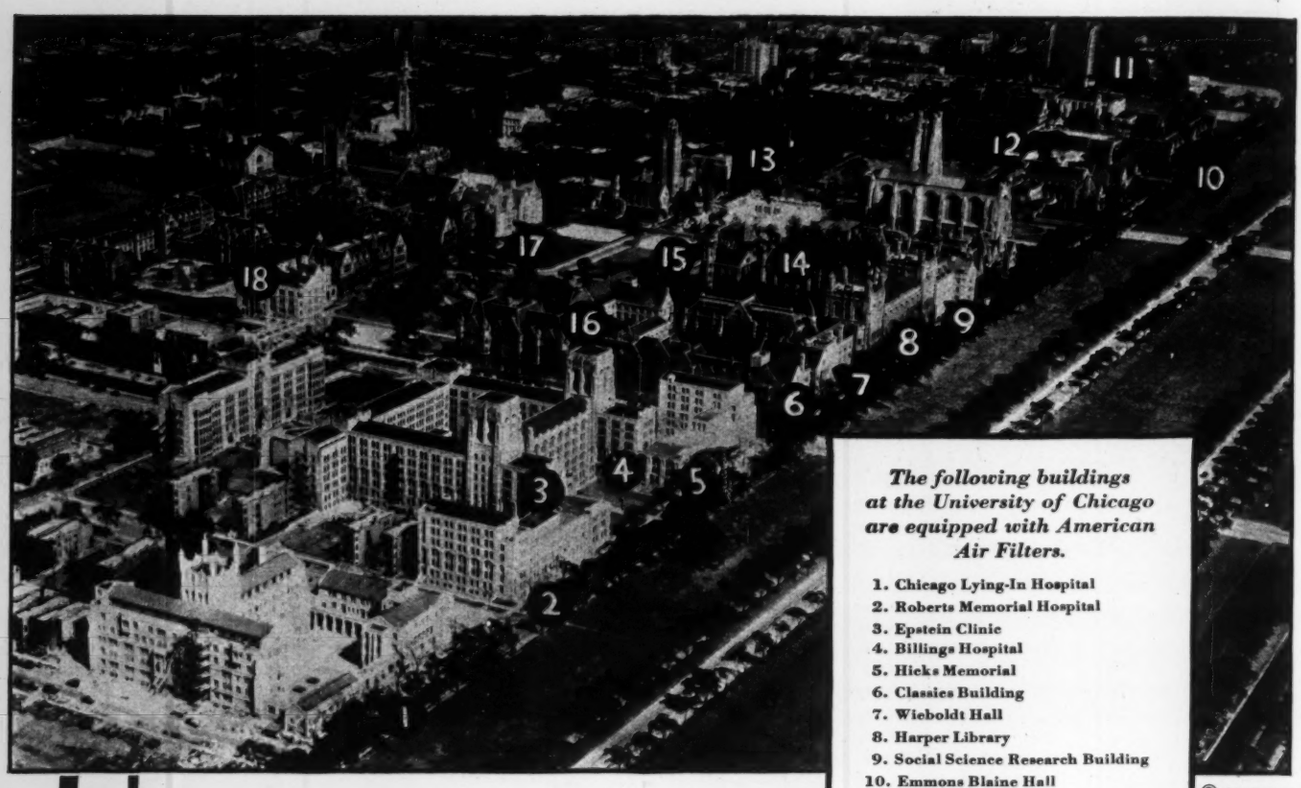
For use with three-wire, low-voltage temperature control equipment

HERE is an electric thermostat that is distinctive not only for its dependable and accurate control, but also for its good appearance. The softly brilliant moulded case and base enclose working parts which are designed to perform effectively the functions for which they are intended, and which are rust-proofed before assembly to assure long life and dependable service. A number of models of the Room Thermostat shown in the illustration are available, being made with or without the thermometer on the case, with or without special cover screws, with or without detents to meet special conditions, and with either internal or external adjustment. These thermostats will actuate the controlled equipment on a temperature variation at the thermostat of 1° or less above or below the set point. Other models of Barber-Colman Room Thermostats having the same characteristics of good looks and accurate control as the above are as follows: Two-Temperature Thermostats, Duplex Thermostats, and Compound Thermostats. Barber-Colman instruments may be used in connection with any type of heating, ventilating or air-conditioning systems, and also for individual units of heating or ventilating equipment. You will be surprised at the low prices at which these good-looking and dependable control instruments can be obtained.

A 48-page catalog describing the Barber-Colman Electric System of Temperature Control will be mailed upon request. Write for your copy today.

BARBER-COLMAN COMPANY
ROCKFORD, ILLINOIS, U. S. A.

The first successful ELECTRIC SYSTEM of Room Temperature Control



The following buildings at the University of Chicago are equipped with American Air Filters.

1. Chicago Lying-In Hospital
2. Roberts Memorial Hospital
3. Epstein Clinic
4. Billings Hospital
5. Hicks Memorial
6. Classics Building
7. Wieboldt Hall
8. Harper Library
9. Social Science Research Building
10. Emmons Blaine Hall
11. Sunny Gymnasium
12. Graduate Education Building
13. Oriental Institute
14. Law School
15. Rosenwald Hall
16. Bond Chapel
17. Eckhart Hall
18. Jones Laboratory

© CHICAGO AERIAL SURVEY CO.

UNIVERSITY OF CHICAGO *Demands Clean Air* ★

★ Eighteen of these beautiful buildings at the University of Chicago are equipped with American Air Filters in line with the aggressive spirit of striving for the best that has built this notable institution of learning on land that 40 years ago was a swamp.

With American Air Filters, Chicago reduces its maintenance costs on furnishings and decorations; protects its equipment from the expensive destruction of dust and dirt; safeguards its students and professors against the reduction in efficiency and attendance that comes with stale, germ-laden air.

Send for facts and figures on savings that are being made by American Air Filters in schools, hospitals, hotels, department stores, public buildings and factories where sanitary products or costly machinery must be protected.

AMERICAN AIR FILTER COMPANY, *Inc.*
107 Central Avenue, Louisville, Kentucky
In Canada, MIDWEST CANADA LTD., Montreal, P. Q.

AMERICAN AIR FILTERS

WELDOLETS

WELDOLETS require only one weld to install. They form permanent, leak-proof junctions.

These Welding Fittings result in substantial economies

THREDOLETS

THREDOLETS are especially adaptable to low pressure plumbing and heating systems. Their outlets are tapped.

The original price of the fitting . . . the cost of installing it . . . its range of applications . . . and the permanency of the completed junction, are the important contributing factors in the selection of welding pipe fittings. It is these factors that combine to result in substantial economies in the maintenance of old piping systems and the installation of new piping.

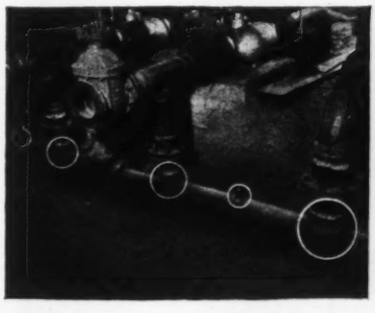
Bonney Weldolets and Thredolets are the right fittings to meet these exacting requirements. These two complete lines of welding fittings have unusually wide ranges of application, are inexpensive to install, and are priced right.

Weldolets and Thredolets are installed with very little manipulation of the branch and without disturbing the alignment of the main pipe. Large reserve strength factors give them extra strength for high pressure work. They show a minimum of shrinkage and distortion in welding. And due to their correct design, the welder always deposits sufficient welding metal at the point where ordinary welded junctions are weakest, to insure a lasting, leak-proof joint.

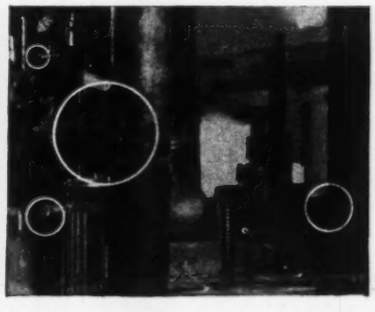
Once you use Bonney Weldolets and Thredolets you will be thoroughly sold on their many outstanding advantages. Therefore we ask you to write for a small size sample. Install and test it, and you will be convinced that you have used a real welding fitting that makes a real job.

BONNEY FORGE *and* TOOL WORKS
Forged Fittings Division, **Allentown, Pa.**
DISTRIBUTORS IN PRINCIPAL CITIES

Bonney Weldolets and Thredolets are made in all standard sizes. Notice the range of sizes illustrated below.



Below: Bonney Weldolets installed in a natural gas regulating station. Operating pressure 600 pounds per square inch.



HP

BONNEY FORGE and TOOL WORKS
Forged Fittings Division,
Allentown, Pa.

KINDLY SEND ME BULLETIN WT12.

NAME_____

COMPANY_____

STREET_____

CITY_____ STATE_____

Replace Your Obsolete and Worn-out Steam Traps With Silvertops

Old, obsolete, worn-out steam traps deserve retirement. In most cases such traps are wasting fuel and are not doing their job, some are clogged, many of them have their valves scored, and some are not even working at all. It is time to replace these veterans with Silvertops, the Anderson Model "A" Inverted Bucket Steam Traps. Silvertop is the newest trap on the market. These inverted bucket traps are the last word in simplicity. They have the fewest possible number of working parts. Valves and valve seats are made of Nitralloy, the finest erosion resisting metal known. Silvertop has as an exclusive feature a deflector with a small orifice in the center in the bottom of the trap which prevents an excess of inflowing condensate from causing the bucket to rise and partially closing the valve. This same deflector washes the heavy sediment not in suspension out of the trap. This deflector gives Silvertop the largest capacity of any similar sized trap on the market. Before you buy any steam trap be sure to investigate "Silvertop", the trap with a copper colored body and a silver colored top. Write today for complete information on this new Model "A" Inverted Bucket Steam Trap.

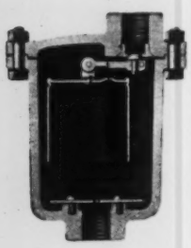
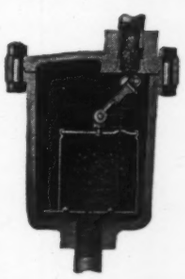


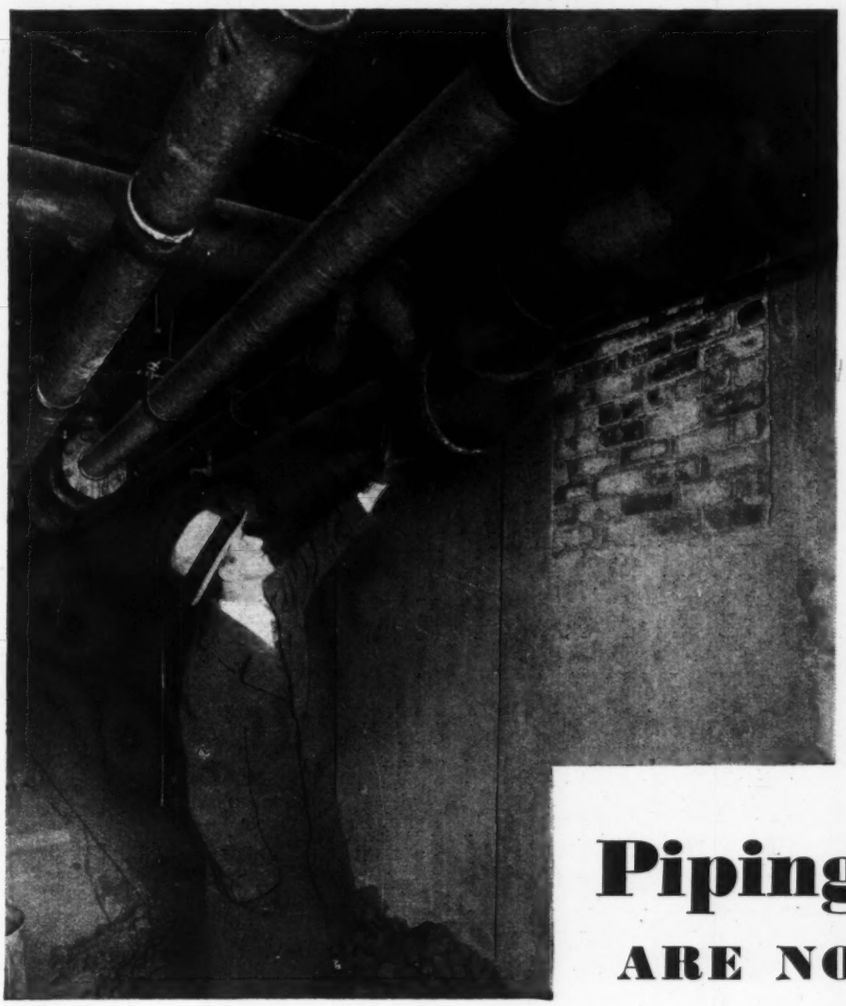
Illustration above is a cross section of "Silvertop" showing the simplicity of working parts and the exclusive deflector.



Cross section of "Silvertop" showing the manner in which air is discharged along with the discharging condensate. Notice the action of the deflector at the bottom.

THE V. D. ANDERSON COMPANY
1934 WEST 96TH STREET · CLEVELAND, OHIO

Arc-welded Joints are Leak-proof and Permanent



An arc-welded joint will not leak . . . it is part of the pipe itself!

Piping Layouts
ARE NO PROBLEM

— when arc welding is employed by the piping contractor.

And it's ten to one that the time required for erection will be much less than by any other method.

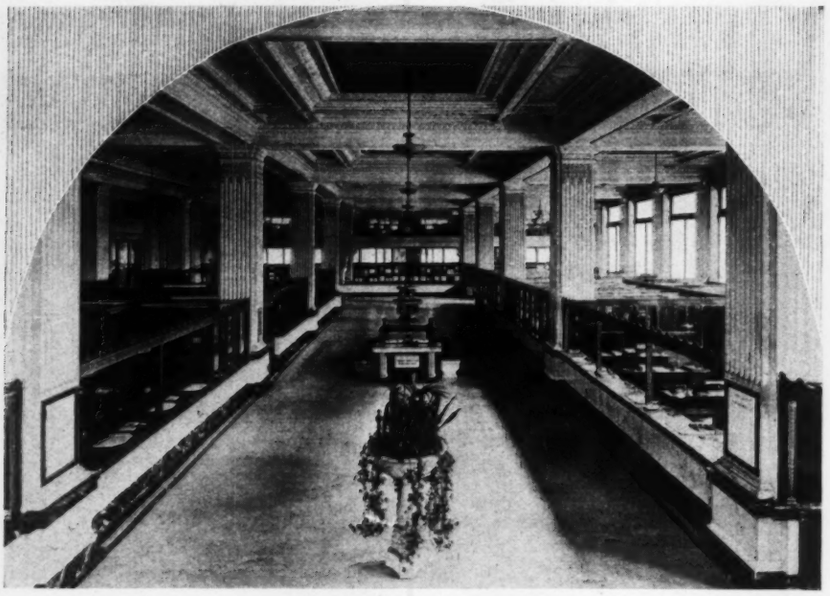
The acceptance of arc welding throughout all industries is growing tremendously. Take advantage of this acceptance—use it as a selling point —arc-weld your next installation.

For the highest speed, economy, and quality of weld, use G-E welding equipment and G-E electrodes—available through your nearest G-E office.

530-119

GENERAL ELECTRIC

SALES AND ENGINEERING SERVICE IN PRINCIPAL CITIES



GREATER PENOBSCOT BUILDING, Detroit. 47 floors, completely equipped with Johnson Control. 2nd to 5th floor Johnson Control on direct radiation and air conditioning. 6th to 47th floor have Johnson Remote Control on riser valves, divided into 36 zones: steam supplied to or shut off from any zone desired.

PALMOLIVE BUILDING, Chicago. Direct radiation 12th, 13th, 14th, 34th, 35th, 36th and 37th floors Johnson Controlled: all ventilating apparatus entire building Johnson Controlled.

DUKE UNIVERSITY HOSPITAL, Durham, N. C. 1,000 Johnson Thermostats control 1,200 valves on direct radiators: Air washers in Pediatric Ward and Operating Rooms controlled by Johnson Dew Point Thermostats: providing complete air conditioning winter and summer. All refrigeration, both storage and scientific Johnson controlled.

FORDSON HIGH SCHOOL, Fordson, Mich. Johnson Dual Thermostat Control on all sources of heat and ventilating units: class rooms, auditorium, gymnasium, swimming pool, business offices, etc.

THE PROPER CONTROL OF HEAT AND HUMIDITY

The Johnson System, established in 1885, remains today the one right method of heat and humidity control. The forty-six years of heat and humidity control experience supporting The Johnson System is substantial surety of reliability in each essential detail. The thousands of Johnson Control installations successfully functioning in buildings of all kinds everywhere are invaluable evidence upon which to correctly decide which control method, and which system is best for you to install . . . . *permanently best after installation is made.*

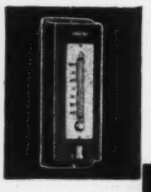
JOHNSON SERVICE COMPANY

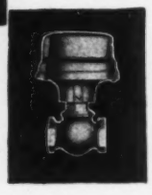
507 E. Michigan St. Established 1885 Milwaukee, Wis.

Albany	Cincinnati	Greensboro, N.C.	Philadelphia	Seattle
Atlanta	Cleveland	Indianapolis	Pittsburgh	Calgary, Alta.
Baltimore	Dallas	Kansas City	Portland	Montreal, Que.
Boston	Denver	Los Angeles	St. Louis	Winnipeg, Man.
Buffalo	Des Moines	Minneapolis	Salt Lake City	Toronto, Ont.
Chicago	Detroit	New York	San Francisco	Vancouver, B. C.

JOHNSON Heat and Humidity Control SERVICE

The All-Metal System, The All-Perfect Graduated Control Of Valves And Damper. The Dual Thermostat (Two Temperature) or (Night And Day) Control, Fuel Saving 25 to 40 per cent.





30 Johnson Branches Insure Convenient, Quick Service Anywhere, Any Time. Each Johnson Installation Made By Johnson Mechanics Only. Every Johnson Installation Given Annual Inspection.

PROPELLAIR
TRADE MARK REG.

Airplane Propeller Exhaust and Ventilating Fans

The CURVED ENTRANCE HOUSING of Propellair Fans has proved its point. Standard Code Tests, conducted in the laboratories of various universities, show that Propellair Fans move more air per horse power and equal diameter propeller than any other airplane-propeller type fan. In addition to a propeller of accurate design, the CURVED ENTRANCE HOUSING, illustrated here and used on all Propellair Fans, properly guides the air currents, offers least resistance to their flow, and enables the full length of the blades to be efficient without restricting the area of the fan outlet.

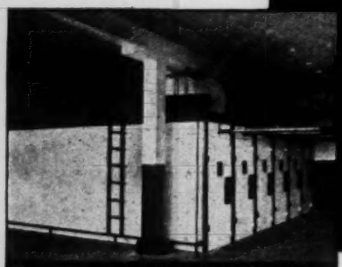
Propellair Fans have non-overloading characteristics, the horse power curve being practically flat from free air condition to maximum static pressure at no air discharge. A safeguard against motor burn-outs—in other words you cannot overload the motor.

An unusual and comprehensive catalog, showing the full line of many styles and models of Propellair Fans, together with other valuable data, will be sent if requested on your letterhead.....

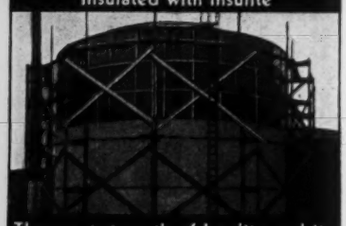
PROPELLAIR-INC
COLUMBUS, OHIO

HEATING AND VENTILATING ENGINEERS *will appreciate these* ADVANTAGES *of* INSULITE

EFFICIENCY
DURABILITY
STRENGTH
ECONOMY
AND EASE OF APPLICATION

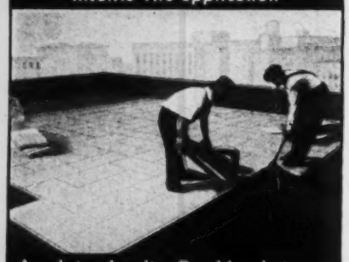


Proof Boxes built by the Union Steel Products Co., Albion, Michigan, insulated with Insulite



The great strength of Insulite and its resistance to moisture make it a superior material for Tank Insulation

Interior view of the Sanitary Laundry at Redlands, California, showing the Insulite Tile application



Applying Insulite Roof Insulation—note the edges do not butt, they overlap—there are no heat leaking joints—the roof is "heat sealed"

THERE are a "hundred and one" uses for Insulite in the heating, ventilating, and air conditioning field—and in every one of these uses, this all wood-fiber insulating board has outstanding advantages that are appreciated by Heating and Ventilating Engineers.

Above all—Insulite has a high thermal insulating efficiency. Its conductivity is .30 to .32 B. T. U. per square foot, per hour, per inch thickness, per degree Fahrenheit. Furthermore—this efficiency is permanent. Insulite is chemically treated to resist moisture and is not subject to rot or disintegration. Insulite left exposed to the elements for over 15 years shows no appreciable loss of tensile strength or insulating value.

Insulite is economical to use. The large rigid panels are easily and quickly installed—saving labor costs and material waste.

As roof insulation, air duct lining, storage tank insulation, for use in laundries, fruit sweat rooms, drying rooms, bakery proof rooms, or wherever temperatures must be maintained and controlled—Insulite is a superior material. May we send you samples and additional information.

USE THIS SERVICE

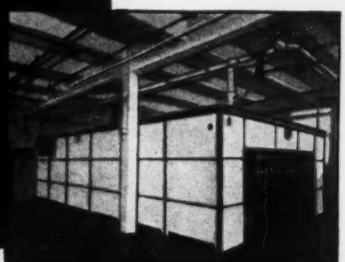
The Insulite Co. maintains a complete Engineering and Laboratory Service, and will gladly co-operate with you or assist with any special insulating problem you may have. There is no obligation on your part.

THE INSULITE CO.

1200 Builders Exchange, Dept. 44L

Minneapolis, Minnesota

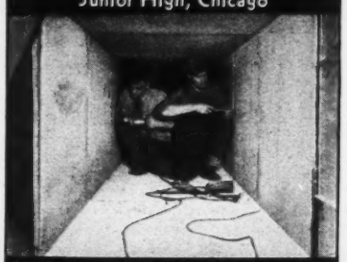
OFFICES IN ALL PRINCIPAL CITIES



A view of the Insulite insulated Drying Room of The Ideal Shoe Company, Milwaukee, Wisconsin

Insulite built Sweat Rooms of the Highlands, California, Mutual Groves Packing Plant

Showing the Acoustile treatment of the Chorus Room of the Farragut Junior High, Chicago

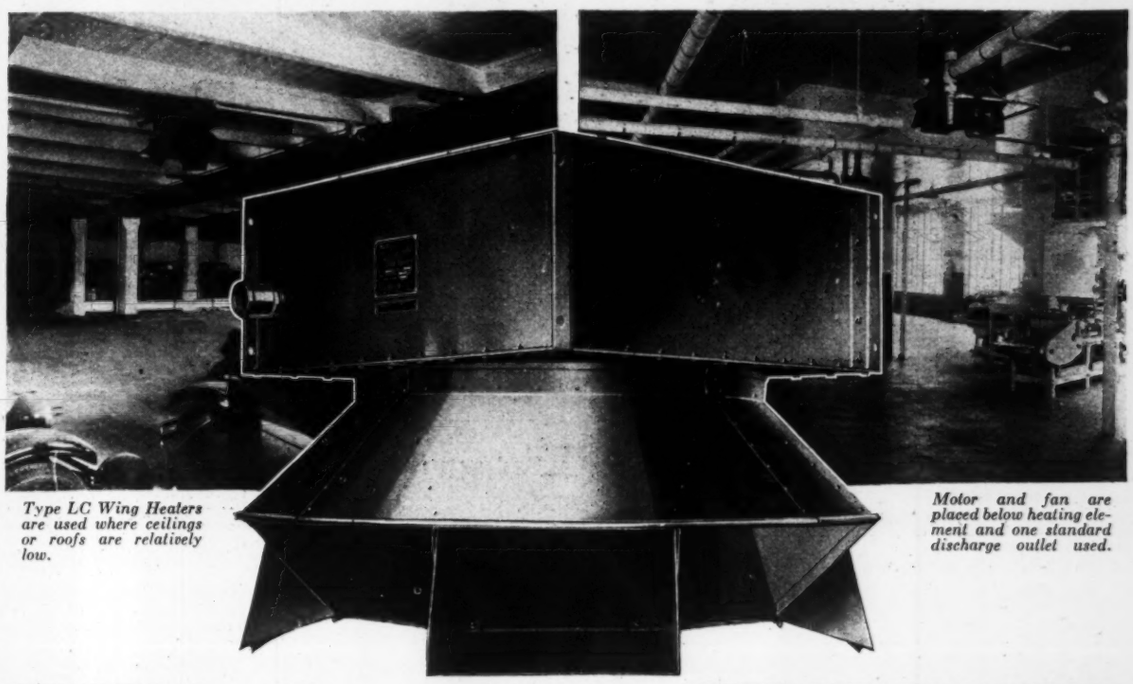


Insulite is especially adapted to duct lining because of its low thermal conductivity and high sound absorbing coefficient

INSULITE

the Wood-Fiber Insulating Board

THERE IS A DIFFERENCE IN UNIT HEATERS



Type LC Wing Heaters are used where ceilings or roofs are relatively low.

Motor and fan are placed below heating element and one standard discharge outlet used.

WING Design is EXCLUSIVE with WING Featherweight Unit Heaters

Wing Featherweight Unit Heaters were the first lightweight unit heaters on the market. Wing design is, therefore, the result of years of experience devoted to solving unit heating problems. The present design of Wing Feather weight Unit Heaters is original and exclusive with Wing Heaters.

The main features are (1) light weight, (2) the vertical downward discharge of the heated air, and (3) multiple discharge outlets.

It is these features that are directly responsible for the great economies possible in industrial plant heating by the use of Wing Featherweight Unit Heaters.

These economies and advantages may be summarized, briefly, as follows:

Economy of Steam—Heated air is projected from the highest point in the room or building, preventing accumulation of heated air at this point. Heat may be controlled, manually or thermostatically. Buildings are heated more rapidly as warmth is felt at floor level as soon as the Wing heaters are started.

Space Conservation—Heaters are removed from working floor and placed overhead.

Comfort—No deadening radiant heat. No cold drafts.

Low Cost of Equipment—Multiple discharge outlets assuring complete and uniform distribution of heat, fewer heaters are required.

Low Installation Cost—Simplicity of piping and fewer units requiring fewer valves, traps, etc., make for economical installation.

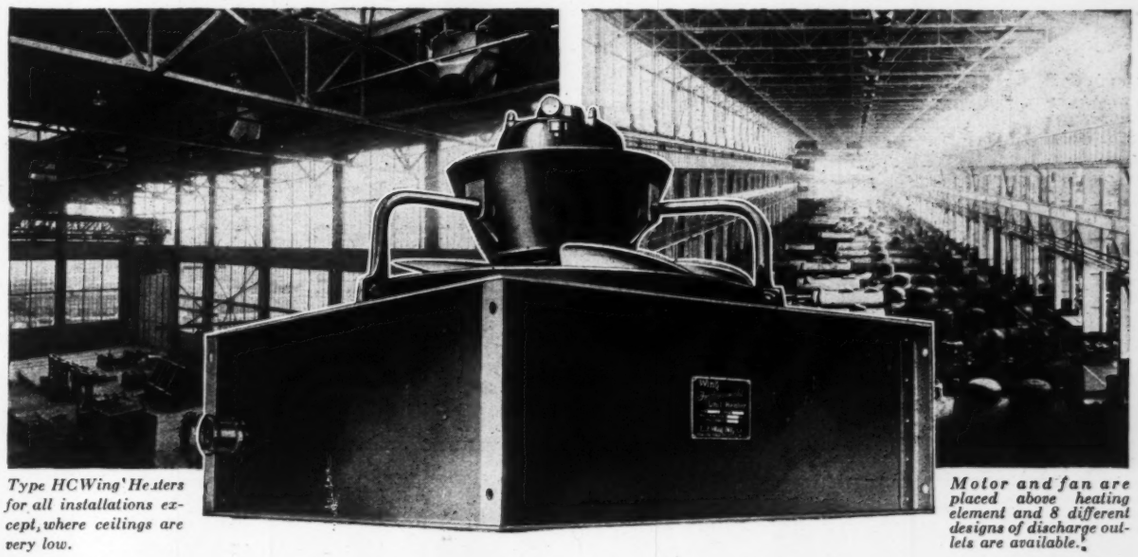
Low Maintenance Cost—Require cleaning and lubricant but once a year. No other maintenance cost.

Write for a copy of our complete catalog, containing a complete discussion of unit heater design and costs. If you have a copy of SWEET'S Engineering Catalogs (1931) you may consult it in that volume.

L. J. WING MFG. CO., 14th Street at 7th Avenue, New York City

Specialists in the Design and manufacture of air-handling equipment since 1878

UNIT HEATERS · FOG ELIMINATORS · EXHAUSTERS · TURBINE BLOWERS · MOTOR DRIVEN BLOWERS · SAFETY VENTILATING FANS · MAN COOLERS



Type HC Wing Heaters for all installations except, where ceilings are very low.

Motor and fan are placed above heating element and 8 different designs of discharge outlets are available.

THE G-E MOTOR SPECIALIST SAYS:

"Cut Maintenance Costs— Specify G-E Motors"

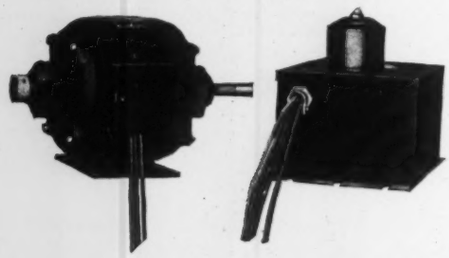
BREAKDOWNS, replacements, repairs, and readjustments on power units often cost far more than expected—unless proper precautions are taken.

The best precaution against excessive maintenance is to specify G-E motors. The long service these motors are able to give, their great strength, their ready accessibility for inspection and lubrication, and their ability to carry normal overloads without damage, all serve to keep maintenance down.

In the complete line of G-E motors you'll always find exactly the right motor for your job. All are included—fractional-horsepower, synchronous, single-phase or multiphase, fan-cooled, low- or high-speed, ball- or sleeve-bearing. Each is the product of years of design, manufacture, and application experience.

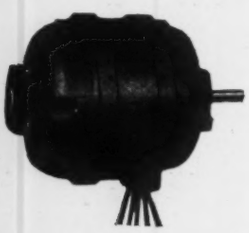
Talk your motor problem over with the G-E motor specialist; he is always ready to coöperate.

G-E MOTORS
for
UNIT HEATERS
UNIT COOLERS
FANS
BLOWERS
HUMIDIFIERS
AIR FILTERS
PUMPS
REFRIGERATION
AIR-CONDITIONING PLANTS

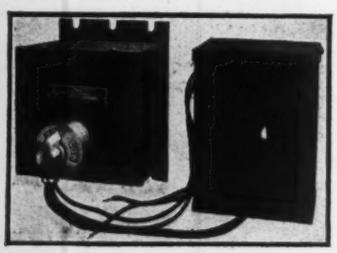


G-E Type KC single-phase variable-speed fractional-horsepower motor with separate capacitor-transformer controller unit

(Below) G-E Capacitor-transformer unit for use with Type KC integral-horsepower motor



(Left) G-E Type KC integral-horsepower motor



210-143

GENERAL ELECTRIC

SALES AND ENGINEERING SERVICE IN PRINCIPAL CITIES

Presto . . . and Escaping Heat is CAPTURED!

You'll say there's magic in the way Controlled Zone Heating saves fuel by holding more heat in the working zone

HUNDREDS of executives in factories, garages and hangars have found one sure way to reduce fuel bills this year—as much as 25%. That way is to stop wasteful overheating of the dead zone.

Controlled Zone Heating discharges streams of warmed air into your factory rooms at high velocity *without drafts*. This air is then drawn down and back to the unit through a low-velocity intake at the floor level. The result: more warmth is held down in the working zone, where you want it.

You also get another big saving through the added feature of Super-Control Regulation. This original device automatically regulates the temperature of the air passing through the unit to balance the continual fluctuations in outside temperature.

All Carrier-York Heat-Diffusing Units are based on this fuel-saving principle—Controlled Zone Heating with Super-Control Regulation.

Why not take a few moments off to find out just how much fuel *you* can save with this improved new heating system—on either new or modernization projects? Your local heating contractor or one of our branch offices will be glad to do the figuring.

HEAT OUTPUT of UNIT
HEAT LOSSES from BUILDING
BALANCED...to maintain uniform, comfortable working conditions... to insure reduced consumption of fuel in exact proportion to fluctuations in outside temperatures...
SUPER-CONTROL REGULATION

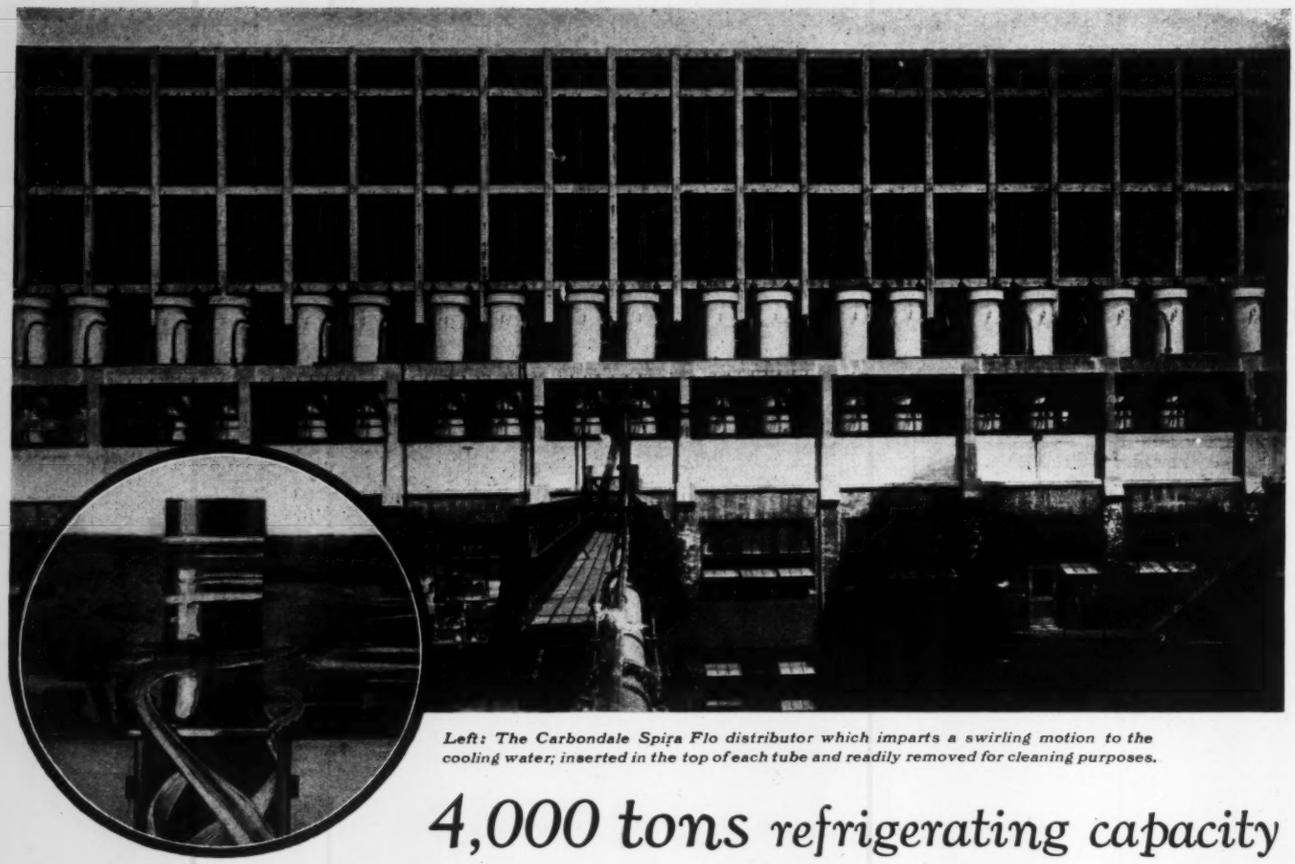
CARRIER-YORK CORPORATION
A Division of Carrier Corporation
(Successor to York Heating & Ventilating Corporation)
1541 Sansom Street Philadelphia, Pa.

Carrier-York

HEAT-DIFFUSING UNITS

HOLD MORE HEAT IN THE WORKING ZONE

20 Spira Flo Ammonia Condensers *serve Armour & Co....*



Left: The Carbondale Spira Flo distributor which imparts a swirling motion to the cooling water; inserted in the top of each tube and readily removed for cleaning purposes.

4,000 tons refrigerating capacity

39,800 square feet of surface is provided by these 20 Carbondale Spira Flo Condensers. Swirling streams of water are in contact with the condenser tubes throughout their entire length. A maximum cooling effect is thus obtained and the head pressure is held close to the limits set by the outlet water temperature.

These condensers combine with other equipment to provide a highly efficient and economical refrigerating system. And Armour & Co., knows from many years experience that to assure dependable refrigeration, the combination of engineering design and workmanship which Carbondale provides is unexcelled.

More than 40 years of pioneering and successful application of refrigeration is at your service when you consult Carbondale. Another advantage, is the complete line of Carbondale Machines for both absorption and compression refrigeration. You are assured the most efficient system for any service.

Whether it be for quick freezing... food preservation... manufacturing ice... a manufacturing process... or air conditioning—when refrigeration is involved it pays to consult Carbondale. The service of our engineering department is freely offered. Just drop us a line.

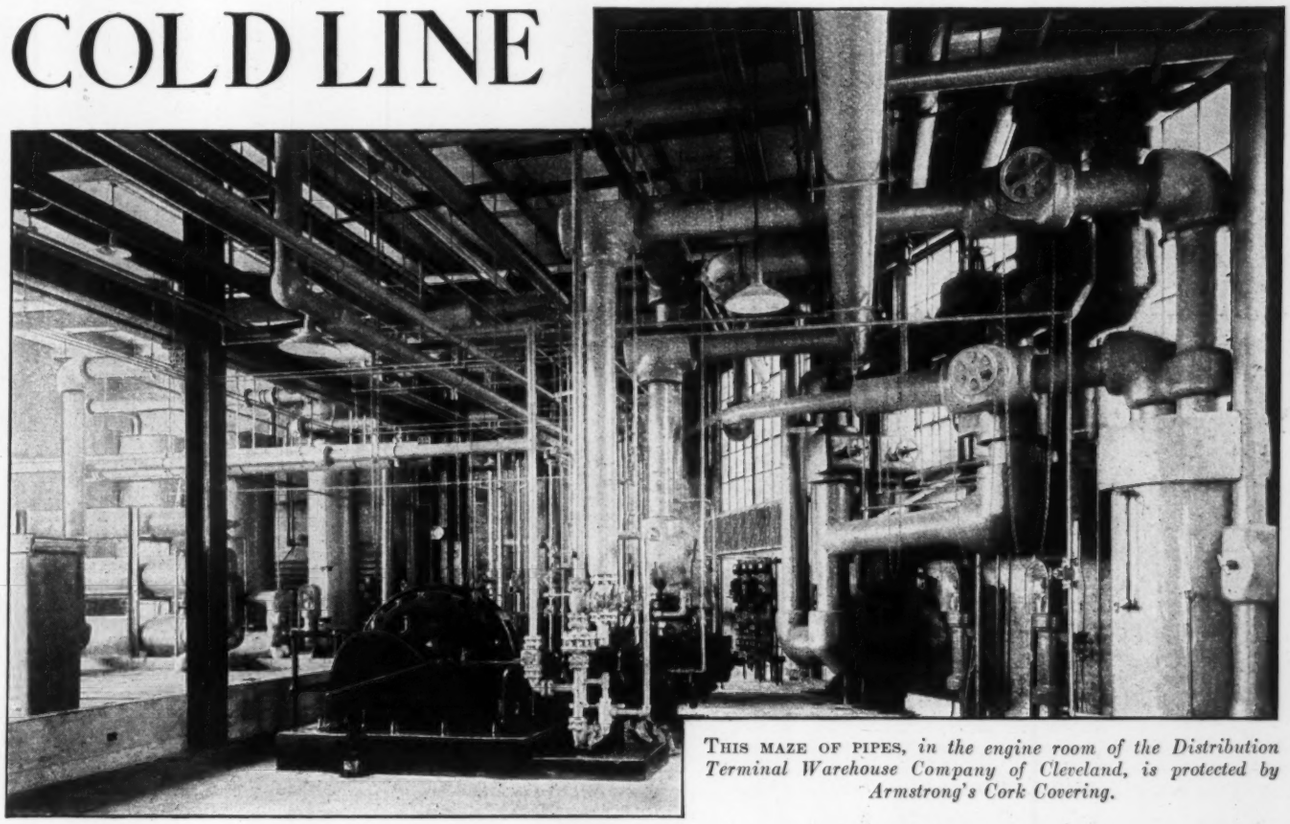
THE CARBONDALE MACHINE CO.
Carbondale, Pa. *Branches in principal cities*
CANADIAN CARBONDALE CO.
102 Lombard Street, Toronto, Ontario

AIR CONDITIONING... HELPFUL data to aid calculations... tables and charts... theoretical problems presented and solved! You will find this book of considerable interest and assistance. Write for a copy.

Carbondale Refrigeration

ABSORPTION AND COMPRESSION AMMONIA CARMALCO SYSTEMS AND CO_2 COMPRESSION SYSTEMS

COLD LINE



THIS MAZE OF PIPES, *in the engine room of the Distribution Terminal Warehouse Company of Cleveland, is protected by Armstrong's Cork Covering.*

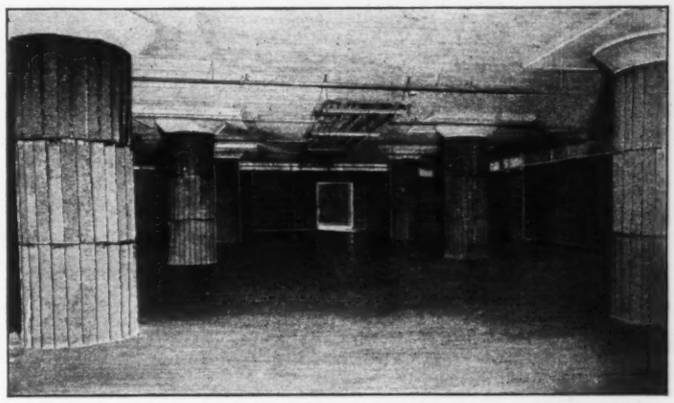
costs cut with CORK!

BE careful of the refrigeration dollars you spend! Costly low temperatures need the protection that cork gives to cold lines. There's two-fold economy when you guard them with Armstrong's Cork Covering. Its high efficiency removes the danger of overloading refrigerating machinery. And its permanent reliability cuts repair bills.

There's no doubt about cork's efficiency. Impressive service records in the ice and cold storage industry over the past quarter of a century testify to its ability to guard low temperatures. And these same records prove that Armstrong's Insulation stands up. Because cork resists moisture, it is not subject to progressive deterioration. It retains its efficiency through years of service.

Part credit for this record is due to the care with which Armstrong engineers plan and erect the insulation. Constant experiment and research have led to a thorough knowledge of the best methods and materials to insure lasting service.

Armstrong's Contract Service can relieve you of the burden of planning and overseeing the erection of insulation in your plant. Armstrong engineers are at your service to help you plan for refrigeration needs, and to tell you more about Armstrong's Insulation Products. Samples will gladly be sent on request. Address Armstrong Cork & Insulation Co., 955 Concord Street, Lancaster, Pa.; Canadian offices in Montreal, Toronto, and Winnipeg.



A MILLION AND A HALF BOARD FEET *of Armstrong's Corkboard guard temperatures in the 12-story building of the Distribution Terminal and Cold Storage Company in Cleveland.*

Armstrong's (A) Product

Armstrong's Corkboard and Cork Covering

FOR ALL COLD ROOMS AND COLD LINES

YOU'LL see this seal on the letters of progressive manufacturers whose products will stand thorough examination by the keenest, most progressive buyers.

DOUBLY IMPORTANT

AN exposition which brings to alert manufacturers the greatest number of potential buyers in the shortest space of time at a minimum expense.

The seller exhibits, explains, demonstrates.
The buyer looks, listens, and chooses.

Both are free from the distractions of their daily work.
They give their undivided attention to the product displayed.

Progressive manufacturers and buyers will make the most of this opportunity.

Buyer and Seller both profit. Will you?

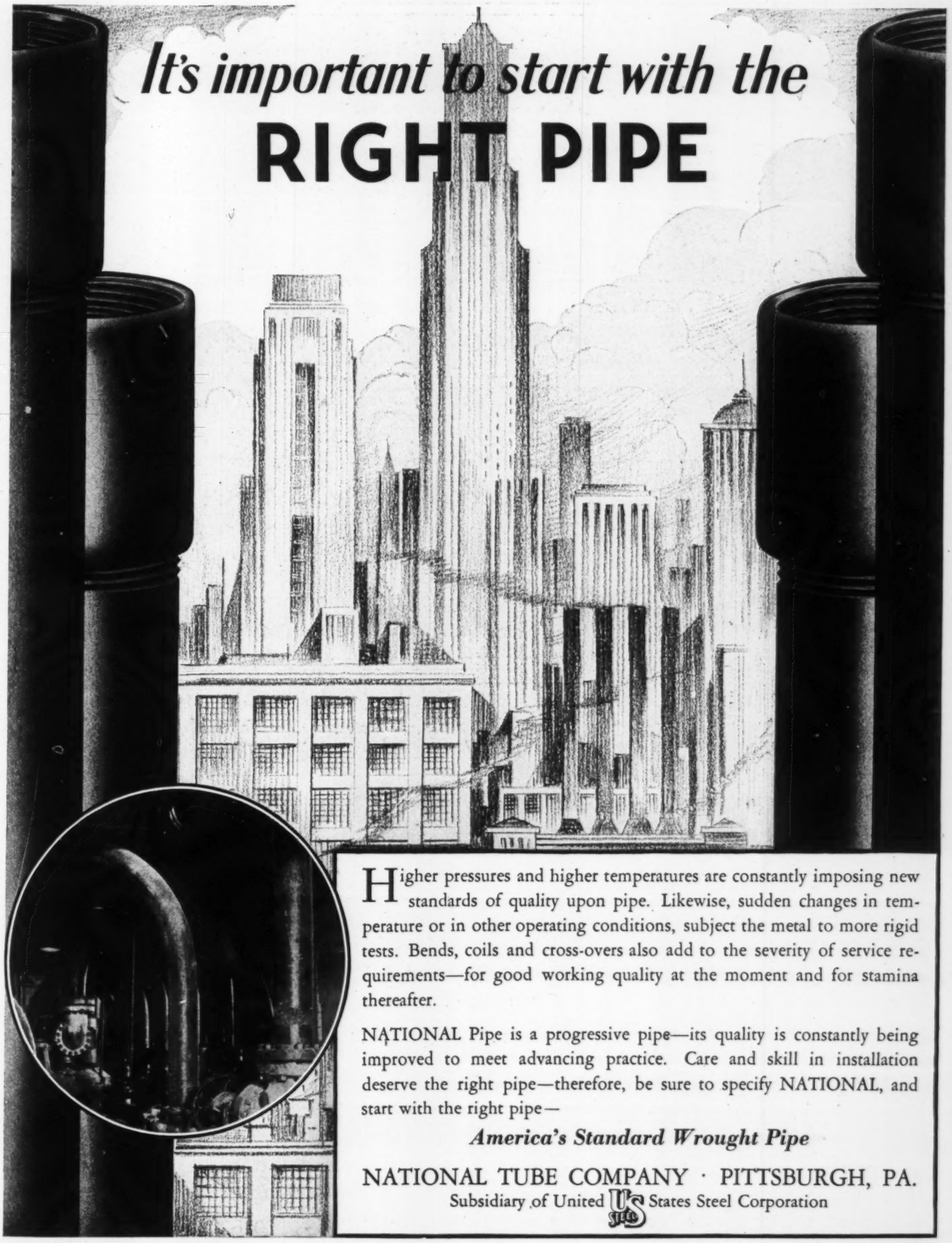
AN INTERNATIONAL EVENT HELD EVERY TWO YEARS

Under the auspices of the American Society of Heating & Ventilating Engineers
Managed by the International Exposition Company

1054

It's important to start with the

RIGHT PIPE



Higher pressures and higher temperatures are constantly imposing new standards of quality upon pipe. Likewise, sudden changes in temperature or in other operating conditions, subject the metal to more rigid tests. Bends, coils and cross-overs also add to the severity of service requirements—for good working quality at the moment and for stamina thereafter.

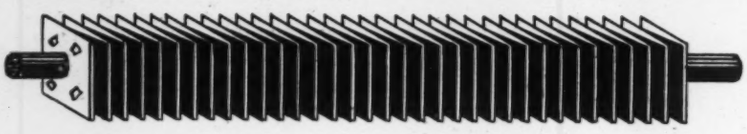
NATIONAL Pipe is a progressive pipe—its quality is constantly being improved to meet advancing practice. Care and skill in installation deserve the right pipe—therefore, be sure to specify NATIONAL, and start with the right pipe—

America's Standard Wrought Pipe

NATIONAL TUBE COMPANY · PITTSBURGH, PA.

Subsidiary of United States Steel Corporation

NATIONAL PIPE



BUSH FINNED TUBING

Has

INCREASED EFFICIENCY, CONSERVED SPACE, OR LOWERED COSTS IN A WIDE VARIETY OF APPLICATIONS

TWENTY ONE STANDARD COMBINATIONS OF FIN AND TUBE SIZES ARE AVAILABLE AND BUSH OFFERS COMPLETE CO-OPERATION WHERE SPECIAL SIZES ARE REQUIRED.

ALUMINUM BRASS COPPER STEEL

THE BUSH MANUFACTURING COMPANY
HARTFORD, CONN.

DISTRIBUTORS' FRANCHISE AVAILABLE IN PRINCIPAL CITIES

The Company You Keep

When your name appears on the reader lists of HEATING, PIPING *and* AIR CONDITIONING, it is among the names of the important men handling this work in the big office buildings, hotels, theatres, hospitals, public utilities, central heating stations, etc., etc.

The problems of these men are like your own. The data and information which the pages of HEATING, PIPING *and* AIR CONDITIONING bring to you each month will help greatly in solving those problems.

A year's subscription to this journal will prove one of the most valuable investments you have ever made. Send your name and address and your check for $3.00, or, if you wish, we will bill you later.

HEATING, PIPING *and* AIR CONDITIONING
1900 Prairie Avenue Chicago, Illinois

SAFER FOR

DANGEROUS LIQUIDS AND SUPERHEATED STEAM

Human life is too valuable to chance valves of inferior metals—particularly when there is danger of the valves cracking. Dangerous liquids and gases are a hazard even when processed under pressures and temperatures that are comparatively moderate.

Thousands of installations prove the absolute reliability of Reading Steel Valves. The electric cast steel is a product of the Reading foundry—widely known for its modern steel casting facilities. The design is so proportioned that the tremendous strains of expansion and contraction are perfectly distributed.

The research and production facilities behind every Reading Electric Cast Steel Valve are highly developed to produce *safe valves* . . . long life valves and valves that require the least amount of maintenance. You are safe when you specify "Reading."

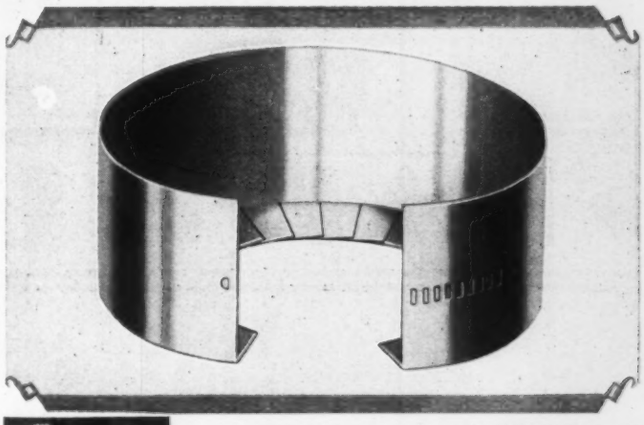
READING-PRATT & CADY CO., *Inc.*
BRIDGEPORT, CONNECTICUT
Offices and Warehouses:
Boston, Charlotte, Chicago, Cleveland, Detroit, Hartford, Houston, New York, Philadelphia, Pittsburgh, Rochester, St. Louis, San Francisco, Tulsa

ACCO

An Associate Company of the American Chain Company, Inc.

READING
Electric Cast Steel
VALVES & FITTINGS

NOW YOU CAN *dress up* EVERY PIPE COVERING JOB



Certainly makes a neat job

Eliminates torn, frayed coverings

CHENEY
ROYAL
PIPE COVERING
PROTECTOR

SNAP ON a Cheney (Royal) Pipe Covering Protector at Floors, Walls, Ceilings, Couplings, Valves, etc., and you'll improve the appearance of every job 100 per cent.

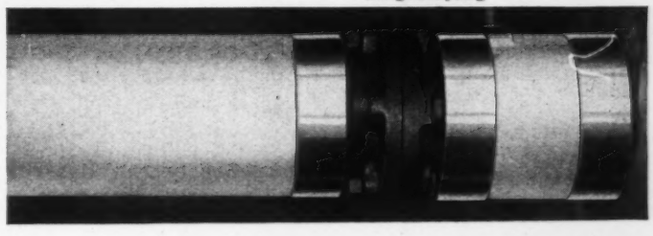
New-Aluminum protector—eliminates torn, ragged, dirty, broken and sifting ends—prevents damage from mops, brushes, vacuum cleaners—and saves time and labor cost of stitching over the ends.

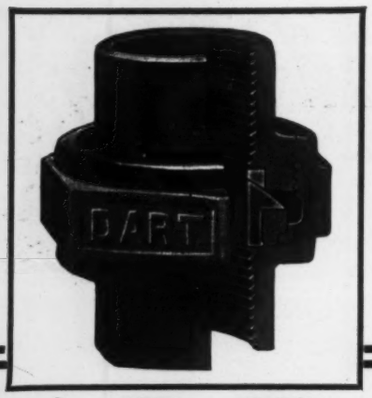
The Cheney Protector is made of 20 gauge Aluminum to fit standard thick coverings with light or heavy canvas. It is 2 inches high and adjustable to circumference variation of 1 inch.

Write Now for more complete details.

THE CHENEY COMPANY
Winchester Massachusetts
New York Philadelphia Pittsburgh Chicago

Below—Actual installation—A smart looking flange coupling





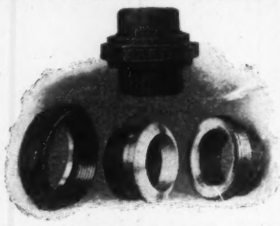
SPECIFY . . . .

•DART UNIONS•

DON'T take a chance with piping Installations. Don't wait until you have to use Dart Unions for replacement. Write them in on original specifications. They assure long life piping jobs.

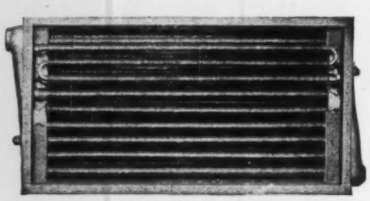
For maintenance and replacement work too, they are your best protection.

2 Bronze Seats



Take a Dart apart yourself. Notice the *two* bronze seats and how they have been ground to a perfect fit.

E. M. DART MFG. COMPANY, PROVIDENCE, R. I.



The Standardized Light-Weight Fan System Heat-Surface

Pressures up to 350 lbs. gauge

Unit illustrated in section is UNIVERSAL AEROFIN, *2½ to 200 lbs.*

Complete information upon request to Newark★

Any Office will gladly render prompt, efficient, technical cooperation

In the World's outstanding Structures,– in the most modern Heating, Ventilating and Air Conditioning Installations

AEROFIN

is the Heat-Surface

Do you not owe it to yourself, and to your Clients or Patrons, to ascertain why this is so?

AEROFIN CORPORATION

850 Frelinghuysen Avenue, NEWARK, N. J.

11 West 42nd Street, NEW YORK

United Artists Building DETROIT

Burnham Bldg. CHICAGO

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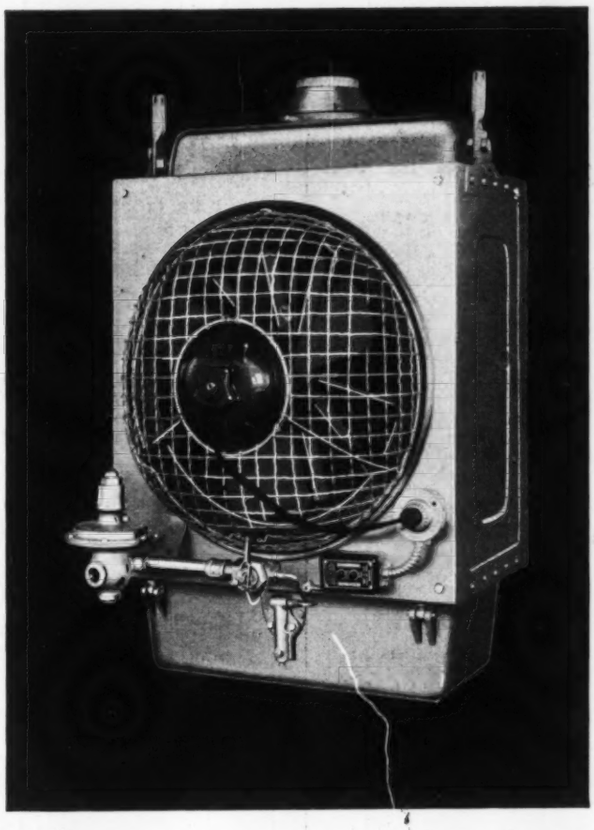
AEROFIN is sold only by Manufacturers of Nationally Advertised Fan System Apparatus.

List upon Request

★*Please mention where you saw this advertisement.*



6 Reasons for Using this Gas Unit Heater

Not in every case, of course, but in many, Buffalo Gas Fired Unit Heaters can provide the most efficient, economical and practical heat obtainable.

Some of the outstanding advantages of this heater are listed—check them:

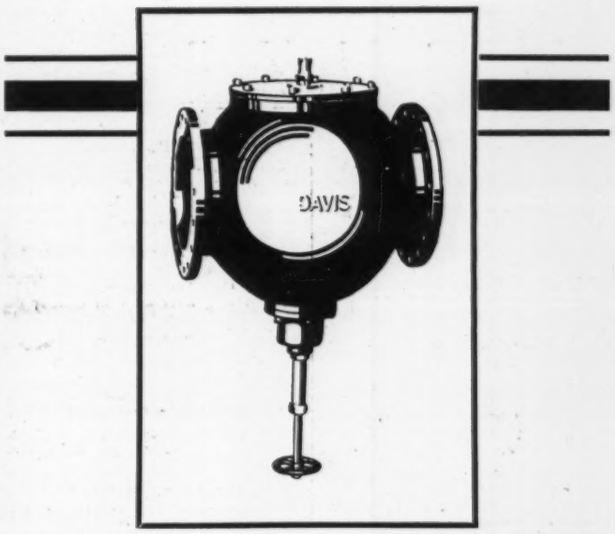
1. The initial cost is low, eliminating boiler room, fuel storage, and auxiliary equipment.
2. The unit is light, compact and easily suspended—no valuable factory space is utilized.
3. Labor expense to operate is negligible—no engineer or fireman—simply push a button to start or stop.
4. The Buffalo Gas Heater is clean—no ashes, dust or smoke.
5. Automatic safety features and temperature control provide economical gas consumption—quick to respond to the heating load.
6. It will admirably act as a booster unit to assist your present heating system—take care of new additions—cold corners.

Where you have occasion again to specify or buy Unit Heaters—be sure to get the full story of the Buffalo Gas Unit Heater before you buy. A complete new catalog is now ready. Write for your copy.

Buffalo Forge Company
171 Mortimer St. Buffalo, N. Y.

In Canada:
CANADIAN BLOWER & FORGE CO., LTD.
KITCHENER, ONTARIO

"Buffalo" GAS Unit Heaters



EXHAUST RELIEF VALVE SERVICE

without maintenance cost!

DAVIS Exhaust Relief Valves have a record of many years service without maintenance cost in industrial power plants and central stations on both turbines and reciprocating engines.

These "condenser safety valves" hold tight under vacuum and relieve to the atmosphere at a fraction of a pound pressure. They have full pipe area through the port and body passages . . . there is no choking of the flow with consequent accumulation of pressure.

Davis Relief Valves are made in horizontal, vertical and angle patterns, in various types and sizes. Send for Catalog 11, which gives details on this and other Davis Automatic Valve Specialties.

DAVIS REGULATOR COMPANY
2546 S. Washtenaw Avenue
CHICAGO, ILLINOIS

DAVIS
AUTOMATIC
VALVE SPECIALTIES

HPAC-12-Gray

BUYERS' GUIDE

ACETYLENE
Air Reduction Sales Co., New York
Linde Air Products Co., New York.

ACETYLENE GENERATING APPARATUS
Air Reduction Sales Co., New York
Linde Air Products Co., New York

ACOUSTICAL MATERIALS
Armstrong Cork & Insulation Co., Lancaster, Pa.

AIR COMPRESSORS
(See Compressors, Air)

AIR CONDITIONING APPARATUS
American Air Filter Co., Inc., Louisville, Ky.
American Moistening Co., Providence, R. I.
Buffalo Forge Co., Buffalo, N. Y.
Carbondale Machine Co., Carbondale, Pa.
Carrier Engineering Corp., Newark, N. J.
Clarage Fan Co., Kalamazoo, Mich.
Garden City Fan Co., Chicago
Grinnell Co., Inc., Providence
Maryland Air Conditioning Corp., Baltimore, Md.
Parks-Cramer Co., Fitchburg, Mass.
York Ice Machinery Corp., York, Pa.

AIR COOLING SYSTEMS
(See Systems)

AIR DRYING SYSTEMS
(See Systems)

AIR ELIMINATORS
(See Eliminators, Air, for Steam and Vacuum Heating)

AIR FILTERS
(See Filters, Air)

AIR SEPARATORS
(See Separators, Air)

AIR WASHERS
(See Washers, Air)

ALARMS, LOW WATER
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Illinois Engineering Co., Chicago

ATOMIZERS
American Moistening Co., Providence, R. I.

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Kewanee Boiler Corp., Kewanee, Ill.

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Cook Electric Co., Chicago
Johnson Service Co., Milwaukee
Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.
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Alexander Brothers, Inc., Philadelphia

BELT CEMENT, WATERPROOF
Alexander Brothers, Inc., Philadelphia

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Alexander Brothers, Inc., Philadelphia.
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Parks-Cramer Co., Fitchburg, Mass.
Philadelphia Pipe Bending Co., Philadelphia
Power Piping Co., Pittsburgh, Pa.
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Roessing Mfg. Co., Sharpsburg, Pa.
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Diehl Mfg. Co., Elizabethport, N. J.
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Clarage Fan Co., Kalamazoo, Mich.
Wing Mfg. Co., L. J., New York

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Wing Mfg. Co., L. J., New York

BLOWERS, TURBO
Wing Mfg. Co., L. J., New York

BOILER COMPOUNDS
(See Compounds, Boiler)

BOILER CONTROLS
(See Controls, Boiler)

BOILERS, COPPER
(See Tanks, Copper)

BOILERS, HEATING, CAST IRON, COAL BURNING
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Burnham Boiler Corp., Irvington, N. Y.

BOILERS, HEATING, GAS BURNING
American Radiator Co., New York
Crane Co., Chicago

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Burnham Boiler Corp., Irvington, N. Y.
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BOILERS, HORIZONTAL, RETURN TUBULAR
Kewanee Boiler Corp., Kewanee, Ill.

100% Strength!

TAYLOR FORGE

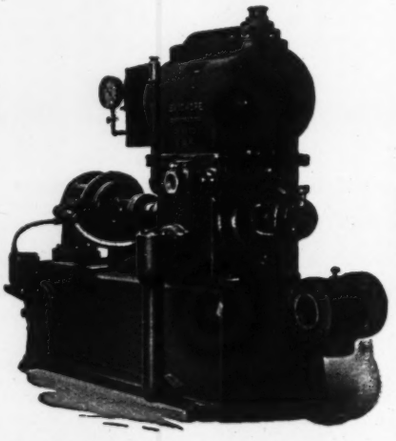
Seamless Steel Fittings for Welding

90° Standard and Long Radius Elbows
45° Elbows
Tees
Reducing Tees
Reducing Nipples
Bull Plugs
Welding Neck Flanges

Specifications in Bulletin 31-1

Taylor Forge & Pipe Works, Chicago
Box 485, Chicago 50 Church St., New York

Ten Years of Service
and Still Going Strong



Skidmore Automatic Vacuum Pump

This is the record of many of the first SKIDMORE VACUUM PUMPS built. Recently a number of our units built in 1922 and 1923 have been tested and found running with practically the same efficiency as the day installed.

SKIDMORE CORPORATION
ST. JOSEPH, MICH.

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CARBIDE
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(See Pumps, Water Circulating)

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Crane Co., Chicago

COCKS, GAUGE
Crane Co., Chicago, Ill.

COCKS, STEAM
Crane Co., Chicago, Ill.

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Crane Co., Chicago, Ill.
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Nichols Products Corp., Detroit

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Crane Co., Chicago.

COMPOUNDS, WELDING
Air Reduction Sales Co., New York
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(See Fittings, Pipe, Brass, for copper service pipe)

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COMPRESSORS, CARBON DIOXIDE
York Ice Machinery Corp., York, Pa.

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CONDENSERS, AMMONIA
Carbondale Machine Co., Carbondale, Pa.
York Ice Machinery Corp., York, Pa.

CONDENSERS, CARBON DIOXIDE
York Ice Machinery Corp., York, Pa.

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American District Steam Co., North Tonawanda, N. Y.
Ric-wil Company, Cleveland, O.

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Johnson Service Co., Milwaukee
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American Radiator Co., New York

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Grinnell Co., Inc., Providence, R. I.

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(See Towers and Ponds, Cooling)

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Parks-Cramer Co., Fitchburg, Mass.

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COUPLINGS, TUBE
Reading Iron Co., Reading, Pa.

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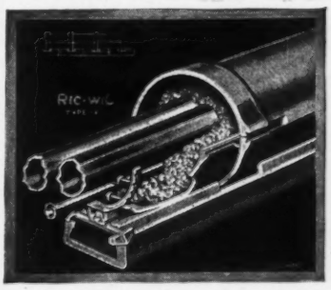
Crane Co., Chicago
Ric-wil Co., The, Cleveland, Ohio

COVERING, PIPE, PROTECTOR
Cheney Co., The, Winchester, Mass.

1300 MILES

THIS un-retouched photograph shows part of a Ric-wiL shipment ready to be installed after being shipped more than 1300 miles. It shows the perfect condition in which Ric-wiL materials land on the job 99 times out of 100 . . . whether shipped a few miles or across the country. It's picture proof of our shipping records which show a breakage of only about one-fourth of one percent.

The completeness of Ric-wiL Systems . . . the elimination of extras . . . the absence of delays, special field construction and engineering . . . the simplicity of Ric-wiL construction . . . all combine to make Ric-wiL Conduit Systems outstandingly low in installation costs.



Ric-wiL Type F Conduit Systems with Dry-paC Waterproof Insulation, insure the highest possible efficiency for underground heating or power pipes. 90% efficiency is guaranteed for this System . . . tests of actual installations show efficiencies up to 95.6%.

Each part of a Ric-wiL System "interlox" with the others to form a compact rigid whole. Sections of the Base Drain stagger with the conduit sections. Pipe supports wedge between sections of Base Drain, resting on Base Drain side shoulders, and extend thru special holes into the conduit to carry the pipes. Top and bottom conduit halves are locked together with the water-tight Loc-liP Side Joint. Ric-wiL Systems are permanent . . . they "stay put".

Ric-wiL Engineers will assist with or furnish plans . . . also supervise installations if desired. Write for Bulletin C-3101 showing photographs of a Ric-wiL multiple pipe installation, using new Base Drain with side shoulders.

OUR CATALOGUE IS FILED IN SWEET'S

THE RIC-WIL COMPANY
1562 Union Trust Building . . . . . Cleveland, Ohio
Branches: New York • Atlanta • Chicago
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REG. U. S. PAT. OFF.

RIC-WIL

CONDUIT SYSTEMS FOR UNDERGROUND STEAM PIPES

COVERINGS, PIPE, WOOD
(See Casing, Pipe, Wood)

COVERING, PIPE, CORK
Armstrong Cork & Insulation Co., Lancaster, Pa.

COVERS AND ENCLOSURES, RADIATOR
American Radiator Co., New York

CUTTERS, PIPE
Crane Co., Chicago

CUTTING APPARATUS, OXY-GAS
Air Reduction Sales Co., New York
Linde Air Products Co., New York

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(See Regulators, Damper)

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Powers Regulator Co., Chicago

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Carrier Engineering Corp., Newark, N. J.
Clarage Fan Co., Kalamazoo, Mich.
Maryland Air Conditioning Corp., Baltimore

DISCS, VALVE
Goetze Gasket & Packing Co., Inc., New Brunswick, N. J.

DRAFT APPLIANCES, MECHANICAL
Buffalo Forge Co., Buffalo, N. Y.

DRYING SYSTEMS
(See Systems, Air Drying)

DUCTS, FUME
Nichols Products Corp., Detroit

DUST COLLECTING SYSTEMS
(See Systems, Dust Collecting)

DUST COLLECTORS
(See Collectors, Dust)

EJECTORS, SEWAGE
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American Radiator Co., New York
American District Steam Co., North Tonawanda, New York
Crane Co., Chicago, Ill.

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American Radiator Co., New York
Hoffman Specialty Co., Waterbury, Conn.
Illinois Engineering Co., Chicago
Sarco Co., Inc., New York City
Trane Co., The, La Crosse, Wis.
Warren Webster & Co., Camden, New Jersey

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Illinois Engineering Co., Chicago
Warren Webster & Co., Camden, N. J.

EQUIPMENT, OIL BURNER IGNITION AND CONTROL
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EXCHANGERS, HEAT
Nichols Products Corp., Detroit

EXHAUSTERS
Buffalo Forge Co., Buffalo, N. Y.

EXHAUST HEADS
(See Heads, Exhaust)

EXHAUST SYSTEMS
(See Systems, Exhaust)

EXPANSION JOINTS
(See Joints, Expansion)

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Clarage Fan Co., Kalamazoo, Mich.
Diehl Mfg. Co., Elizabethport, N. J.
Garden City Fan Co., Chicago
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Torrington Mfg. Co., Torrington, Conn.
Wing Mfg. Co., L. J., New York

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(See Heaters, Feed Water)

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York Ice Machinery Corp., York, Pa.

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Tube Turns, Inc., Louisville, Ky.

FITTINGS, BRASS, STEAM PATTERN
Kennedy Valve Mfg. Co., Elmira, N. Y.
Tube Turns, Inc., Louisville, Ky.

FITTINGS, BRINE
York Ice Machinery Corp., York, Pa.

FITTINGS, CARBON DIOXIDE
York Ice Machinery Corp., York, Pa.

FITTINGS, CAST STEEL
Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.

FITTINGS, CONDUIT, UNDERGROUND
American District Steam Co., North Tonawanda, New York
Kennedy Valve Mfg. Co., Elmira, N. Y.
Ric-wil Company, Cleveland, Ohio
Tube Turns, Inc., Louisville, Ky.

FITTINGS, PIPE, BRASS, FOR COPPER SERVICE PIPE
Bonney Forge & Tool Works, Allentown, Pa.
Kennedy Valve Mfg. Co., Elmira, N. Y.

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American District Steam Co., North Tonawanda, New York.
Crane Co., Chicago, Ill.
Grinnell Co., Inc., Providence, R. I.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Lynchburg Foundry Co., Lynchburg, Va.
Midwest Piping & Supply Co., Inc., St. Louis, Mo.
Power Piping Co., Pittsburgh
Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.

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Kennedy Valve Mfg. Co., Elmira, N. Y.
Midwest Piping & Supply Co., Inc., St. Louis, Mo.
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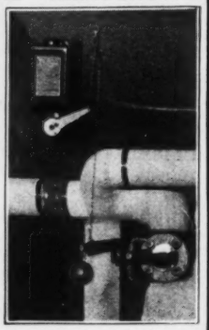
VAPOR MOTOR

SIMPLE—RELIABLE—ECONOMICAL—INEXPENSIVE

For Controlling Shutters, Valves, etc., on Heating, Air Conditioning and Cooking Devices

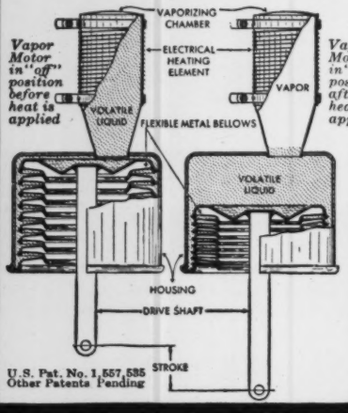
COOK VAPOR MOTOR is an electrical device that produces power without friction. It contains no electric motor, gears or springs. It requires no lubrication, no attention whatever. It will last a lifetime.

The length of stroke, timing and power developed can be varied over a wide range.



Application of a Vapor Motor on a hot water riser.

Detailed information and estimates furnished on request.



U. S. Pat. No. 1,557,585 Other Patents Pending

Technical Data Required for Estimates

1. Length of stroke.
2. Pressure on drive shaft (pounds).
3. Temperature in which device operates.
4. Electric current—volts, cycles.
5. Timing of operating cycle.
6. Device on which vapor motor is to be used.

Mfd. by **Cook Electric Co., 2700 Southport Ave., Chicago, Ill.**

Bends For Extreme Pressure

Power Piping
FOR EVERY INDUSTRIAL NEED

Hollow Bored Steel Forgings bent, flanged and tested to 8000 pounds ✣ illustration shows 8" O.D. x 5" I.D.

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PITTSBURGH, PA.

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(Wrought or Cast)
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Tube Turns, Inc., Louisville, Ky.

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Grinnell Co., Inc., Providence, R. I.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Midwest Piping & Supply Co., Inc., St. Louis, Mo.
Power Piping Co., Pittsburgh
Reading Iron Co., Reading, Pa.
Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.

FITTINGS, PIPE, STEEL
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Crane Co., Chicago, Ill.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Midwest Piping & Supply Co., Inc. St. Louis, Mo.
Power Piping Co., Pittsburgh
Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.
Taylor Forge & Pipe Works, Chicago
Tube Turns, Inc., Louisville, Ky.

FITTINGS, PIPE, WELDING
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Crane Co., Chicago, Ill.
Grinnell Co., Inc., Providence, R. I.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Midwest Piping & Supply Co., Inc., St. Louis, Mo.
Power Piping Co., Pittsburgh
Reading Iron Co., Reading, Pa.
Taylor Forge & Pipe Works, Chicago
Tube Turns, Inc., Louisville, Ky.

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Crane Co., Chicago, Ill.
Grinnell Co., Inc., Providence, R. I.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Tube Turns, Inc., Louisville, Ky.

FITTINGS, VACUUM
Kennedy Valve Mfg. Co., Elmira, N. Y.
Tube Turns, Inc., Louisville, Ky.

FLANGES
American District Steam Co., North Tonowanda, New York
Bonney Forge & Tool Works, Allentown, Pa.
Crane Co., Chicago, Ill.
Grinnell Co., Inc., Providence, R. I.
Midwest Piping & Supply Co., Inc., St. Louis, Mo.
Power Piping Co., Pittsburgh
Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.
Roessing Mfg. Co., Sharpsburg, Pa.

FLANGES, CAST IRON
Lynchburg Foundry Co., Lynchburg, Va.

FLANGES, STEEL PIPE
Bonney Forge & Tool Works, Allentown, Pa.
Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.
Taylor Forge & Pipe Works, Chicago

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Nicholson & Co., W. H., Wilkes-Barre, Pa.

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Crane Co., Chicago, Ill.

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GASKETS, METALLIC
Crane Co., Chicago, Ill.
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GAS, WELDING
Air Reduction Sales Co., New York
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(See Boards, Gauge)

GAUGE GLASSES
(See Glasses, Gauge)

GAUGES, AIR
Crane Co., Chicago, Ill.

GAUGES, ALTITUDE
American Radiator Co., New York
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GAUGES, COMPOUND
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Crane Co., Chicago, Ill.
Hoffman Specialty Co., Waterbury, Connecticut

GAUGES, EXPANSION TANK
American Radiator Co., New York

GAUGES, INDICATING AND RECORDING
(See Instruments)

GAUGES, MERCURY
Grinnell Co., Inc., Providence, R. I.

GAUGES, OIL
Crane Co., Chicago, Ill.

GAUGES, PRESSURE
Air Reduction Sales Co., New York
Bristol Co., Waterbury, Conn.
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Linde Air Products Co., New York

GAUGES, VACUUM
Bristol Co., Waterbury, Conn.
Crane Co., Chicago, Ill.
Foxboro Co., The, Foxboro, Mass.
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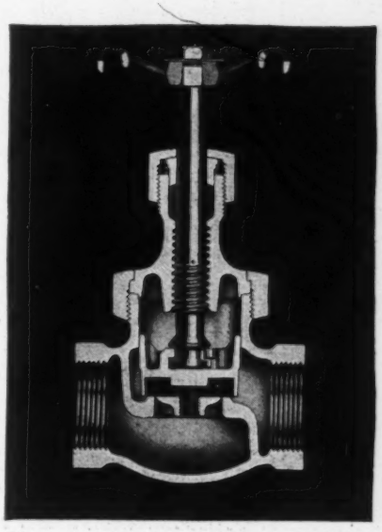

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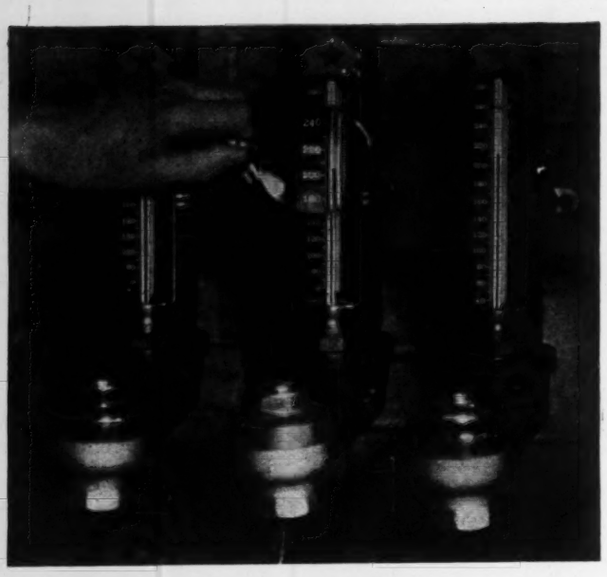

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Nelson Corp., Herman, Moline, Ill.
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(See Systems)

HEATING SYSTEMS, VAPOR

(See Systems)

HEATING SYSTEMS, WATER

(See Systems)

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METERS, FLOW
American District Steam Co., N. Tonawanda, N. Y.

METERS, STEAM
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(See Machines)

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Buffalo Pumps, Inc., Buffalo, N. Y.
Nash Engineering Co., So. Norwalk, Conn.
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Buffalo Pumps, Inc., Buffalo, N. Y.
Hoffman Specialty Co., Waterbury, Conn.
Nash Engineering Co., So. Norwalk, Conn.
Skidmore Corp., St. Joseph, Mich.
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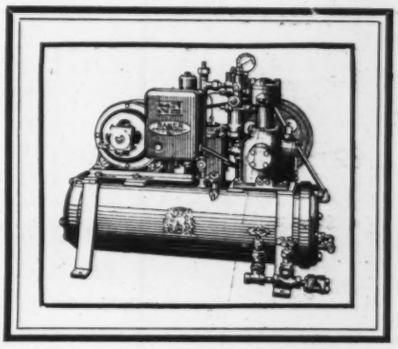

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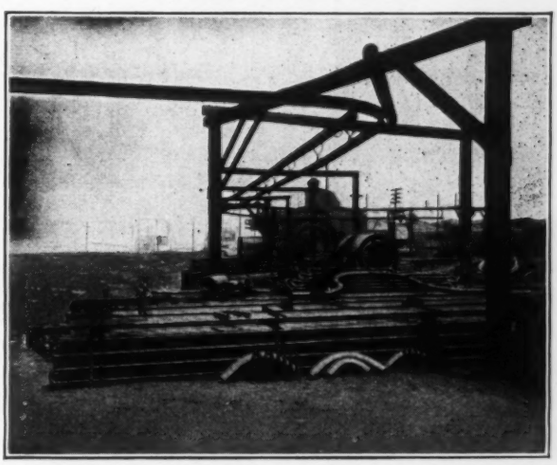

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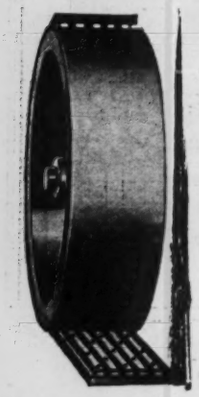

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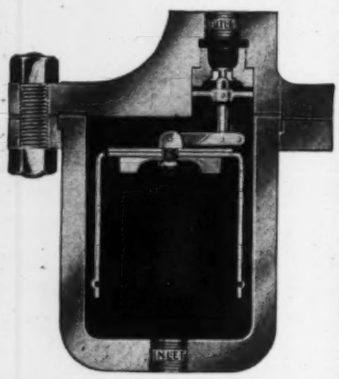

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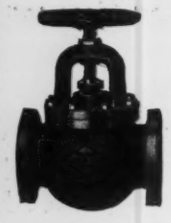

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Ames Pump Co., Inc., New York

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Skidmore Corp., St. Joseph, Mich.

PUMPS, SEWAGE
Nash Engineering Co., So. Norwalk, Conn.

PUMPS, SHALLOW WELL
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Buffalo Pumps, Inc., Buffalo, N. Y.
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Skidmore Corp., St. Joseph, Mich.

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Buffalo Pumps, Inc., Buffalo, N. Y.
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RADIATOR HANGERS
(See Hangers or Brackets, Radiator)

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Nelson Corp., Herman, Moline, Ill.

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American Radiator Co., New York
Crane Co., Chicago, Ill.
Kewanee Boiler Corp., Kewanee, Ill.

RADIATORS, COPPER
Modine Mfg. Co., Racine, Wis.

RADIATORS, INDIRECT
American Radiator Co., New York

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Nash Engineering Co., So. Norwalk, Conn.
Philadelphia Pipe Bending Co., Philadelphia.
Roessing Mfg. Co., Sharpsburg, Pa.

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Carbondale Machine Co., Carbondale, Pa.

RECEIVERS, CONDENSATION
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Crane Co., Chicago, Ill.
Hoffman Specialty Co., Waterbury, Connecticut
Illinois Engineering Co., Chicago
Nash Engineering Co., So. Norwalk, Conn.
Roessing Mfg. Co., Sharpsburg, Pa.
Skidmore Corp., St. Joseph, Mich.

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Roessing Mfg. Co., Sharpsburg, Pa.
York Ice Machinery Corp., York, Pa.

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Carrier Engineering Corp., Newark, N. J.

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(See Governors, Boiler Feed)

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Illinois Engineering Co., Chicago
Mason Regulator Co., Boston
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Grinnell Co., Inc., Providence, R. I.
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Maryland Air Conditioning Corp., Baltimore, Md.
Mason Regulator Co., Boston
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Powers Regulator Co., Chicago, Ill.

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Mason Regulator Co., Boston
Strong, Carlisle & Hammond Co., Cleveland

REGULATORS, PRESSURE, FOR OXY-ACETYLENE WELDING AND CUTTING
Air Reduction Sales Co., New York

REGULATORS, ROOM TEMPERATURE
American Radiator Co., New York
Barber-Colman Co., Rockford, Ill.
Cook Electric Co., Chicago, Ill.
General Electric Co., Schenectady, N. Y.
Johnson Service Co., Milwaukee
Mason Regulator Co., Boston
Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.
Penn Heat Control Co., Philadelphia
Powers Regulator Co., Chicago
Sarco Co., Inc., New York City
Trane Co., The, La Crosse, Wis.

REGULATORS, TEMPERATURE (Liquids, Gases, Etc.)
American Radiator Co., New York
Barber-Colman Co., Rockford, Ill.
Bristol Co., Waterbury, Conn.
Illinois Engineering Co., Chicago
Johnson Service Co., Milwaukee
Mason Regulator Co., Boston
Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.
Powers Regulator Co., Chicago
Sarco Co., Inc., New York City

REGULATORS, WELDING APPARATUS
Air Reduction Sales Co., New York
Linde Air Products Co., New York

REHEATERS, AIR
Nichols Products Corp., Detroit
Trane Co., The, La Crosse, Wis.

SAWS, HACK
Crane Co., Chicago, Ill.

SEPARATORS, AIR
Crane Co., Chicago, Ill.
Illinois Engineering Co., Chicago
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Strong, Carlisle & Hammond Co., Cleveland

SEPARATORS, AMMONIA
Carbondale Machine Co., Carbondale, Pa.

SEPARATORS, OIL
Crane Co., Chicago, Ill.
Illinois Engineering Co., Chicago
National Pipe Bending Co., New Haven, Conn.
Strong, Carlisle & Hammond Co., Cleveland
Warren Webster & Co., Camden, New Jersey

SEPARATORS, STEAM
Crane Co., Chicago, Ill.
Illinois Engineering Co., Chicago
Power Piping Co., Pittsburgh
Strong, Carlisle & Hammond Co., Cleveland
Warren Webster & Co., Camden, N. J.

SHEET METAL WORK
Nichols Products Corp., Detroit

SHIELDS, VALVE STEM
York Ice Machinery Corp., York, Pa.

SOFTENERS, WATER, AUTOMATIC
Crane Co., Chicago, Ill.

SPRAY COOLING SYSTEMS
(See Systems)

SPRAY NOZZLES
(See Nozzles, Spray)

SPRINKLER HEADS
(See Heads, Sprinkler)

STEAM COCKS
(See Cocks, Steam)

STEEL, SHEET
Youngstown Sheet & Tube Co., Youngstown, Ohio

STOCKS AND DIES
Crane Co., Chicago, Ill.

STOKERS
Detroit Stoker Co., Detroit

STOKERS, MECHANICAL
Detroit Stoker Co., Detroit

STOKERS, SIDE CLEANING
Detroit Stoker Co., Detroit

STOKERS, UNDERFEED
Detroit Stoker Co., Detroit

STOPS, ENGINE
Strong, Carlisle & Hammond Co., Cleveland

STRAINERS, STEAM
Illinois Engineering Co., Chicago
Sarco Co., Inc., New York City
Strong, Carlisle & Hammond Co., Cleveland.
Warren Webster & Co., Camden, N. J.

STRAINERS, WATER
Crane Co., Chicago, Ill.
Illinois Engineering Co., Chicago
Sarco Co., Inc., New York City
Strong, Carlisle & Hammond Co., Cleveland.

SUPPORTS, PIPE, CAST IRON
(For Underground Conduit)
Ric-wil Company, The, Cleveland

SWITCHES, PNEUMATIC
Powers Regulator Co., Chicago

SYSTEMS, AIR CONDITIONING
American Air Filter Co., Inc., Louisville, Ky.
American Blower Corp., Detroit
Buffalo Forge Co., Buffalo, N. Y.
Carrier Engineering Corp., Newark, N. J.
Clarage Fan Co., Kalamazoo, Mich.
Grinnell Co., Inc., Providence, R. I.
Maryland Air Conditioning Corp., Baltimore, Md.
Parks-Cramer Co., Fitchburg, Mass.
Trane Co., The, La Crosse, Wis.

SYSTEMS, AIR COOLING
Buffalo Forge Co., Buffalo, N. Y.
Carrier Engineering Corp., Newark, N. J.
Clarage Fan Co., Kalamazoo, Mich.
Maryland Air Conditioning Corp., Baltimore, Md.
Trane Co., The, La Crosse, Wis.

SYSTEMS, AIR DRYING
Buffalo Forge Co., Buffalo, N. Y.
Carrier Engineering Corp., Newark, N. J.
Clarage Fan Co., Kalamazoo, Mich.
Maryland Air Conditioning Corp., Baltimore, Md.
Nichols Products Corp., Detroit
Trane Co., The, La Crosse, Wis.

SYSTEMS, AIR WASHING
American Moistening Co., Providence, R. I.
Buffalo Forge Co., Buffalo, N. Y.
Carrier Engineering Corp., Newark, New Jersey
Clarage Fan Co., Kalamazoo, Mich.
Maryland Air Conditioning Corp., Baltimore, Md.

SYSTEMS, DRYING
Nichols Products Corp., Detroit

SYSTEMS, DUST COLLECTING
American Air Filter Co., Inc., Louisville, Ky.
Buffalo Forge Co., Buffalo, N. Y.
Clarage Fan Co., Kalamazoo, Mich.
Garden City Fan Co., Chicago
Nichols Products Corp., Detroit

SYSTEMS, EXHAUST
Buffalo Forge Co., Buffalo, N. Y.
Clarage Fan Co., Kalamazoo, Mich.
Nichols Products Corp., Detroit

SYSTEMS, HEATING, BLOWER
Buffalo Forge Co., Buffalo, N. Y.
Clarage Fan Co., Kalamazoo, Mich.
Nichols Products Corp., Detroit

SYSTEMS, HEATING, INDUSTRIAL
Nichols Products Corp., Detroit

SYSTEMS, HEATING, VACUUM
Ames Pump Co., New York City
Barnes & Jones, Jamaica Plain, Massachusetts
Crane Co., Chicago, Ill.
Hoffman Specialty Co., Waterbury, Connecticut
Illinois Engineering Co., Chicago
Nash Engineering Co., So. Norwalk, Conn.
Sarco Co., Inc., New York City
Trane Co., The, La Crosse, Wis.
Warren Webster & Co., Camden, N. J.

SYSTEMS, HEATING, VAPOR
American District Steam Co., N. Tonawanda, New York
Barnes & Jones, Jamaica Plain, Massachusetts
Hoffman Specialty Co., Waterbury, Conn.
Illinois Engineering Co., Chicago
Sarco Co., Inc., New York City
Trane Co., The, La Crosse, Wis.
Warren Webster & Co., Camden, N. J.

SYSTEMS, HEATING, WATER
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Crane Co., Chicago, Ill.
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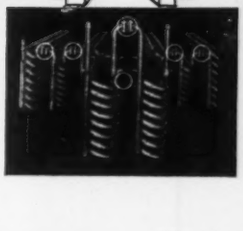

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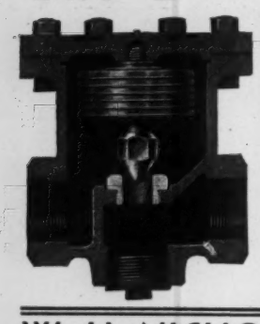

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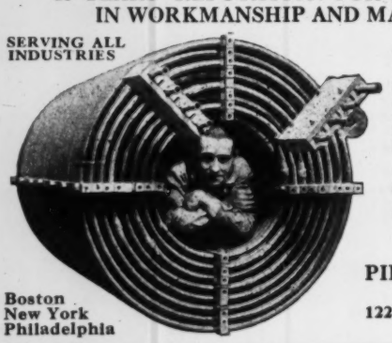

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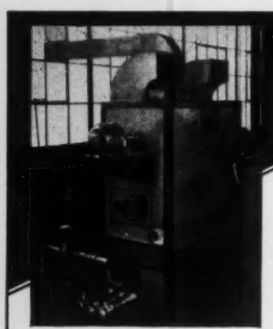

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Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.
Trane Co., The, La Crosse, Wis.

SYSTEMS, SPRAY COOLING
Buffalo Forge Co., Buffalo, N. Y.

SYSTEMS, TEMPERATURE CONTROL
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Bristol Co., Waterbury, Conn.
Carrier Engineering Corp., Newark, New Jersey
Foxboro Co., The, Foxboro, Mass.
General Electric Co., Schenectady, N. Y.
Illinois Engineering Co., Chicago
Johnson Service Co., Milwaukee
Maryland Air Conditioning Corp., Baltimore, Md.
Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.
Penn Heat Control Co., Philadelphia
Powers Regulator Co., Chicago
Sarco Co., Inc., New York
Trane Co., The, La Crosse, Wis.

SYSTEMS, VENTILATING
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Buffalo Forge Co., Buffalo, N. Y.
Carrier Engineering Corp., Newark, New Jersey
Clarage Fan Co., Kalamazoo, Mich.
Maryland Air Conditioning Corp., Baltimore, Md.
Nelson Corp., Herman, Moline, Ill.
Nichols Products Corp., Detroit
Trane Co., The, La Crosse, Wis.
Wing Mfg. Co., L. J., New York

TANKS, ACETYLENE GAS
Air Reduction Sales Co., New York
Linde Air Products Co., New York

TANKS, AMMONIA
Carbondale Machine Co., Carbondale, Pa.

TANKS, EXPANSION
American Radiator Co., New York

TANKS, RECEIVER
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TEMPERATURE CONTROL
(See Systems, Temperature Control)

THERMOMETERS, INDICATING AND RECORDING
(See Instruments, Indicating and Recording)

THERMOSTATS
(See Regulators, Room Temperature)

TORCHES, BLOW, ACETYLENE
Linde Air Products Co., New York

TORCHES, CUTTING, WELDING, OXY-ACETYLENE
Air Reduction Sales Co., New York
Linde Air Products Co., New York

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Buffalo Forge Co., Buffalo, N. Y

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Armstrong Machine Works, Three Rivers, Mich.

TRAPS, AMMONIA
Armstrong Machine Works, Three Rivers, Mich.
Carbondale Machine Co., Carbondale, Pa.

TRAPS, BLAST
American District Steam Co., North Tonawanda, N. Y.
American Radiator Co., New York
Armstrong Machine Works, Three Rivers, Mich.
Barnes & Jones, Jamaica Plain, Mass.
Crane Co., Chicago, Ill.
Hoffman Specialty Co., Waterbury, Conn.
Illinois Engineering Co., Chicago
Sarco Co., Inc., New York City
Strong, Carlisle & Hammond Co., Cleveland
Trane Co., The, La Crosse, Wis.
Warren Webster & Co., Camden, N. J.

TRAPS, GASOLINE
Anderson Co., The V. D., Cleveland, O.
Armstrong Machine Works, Three Rivers, Mich.

TRAPS, OIL AND GREASE
Armstrong Machine Works, Three Rivers, Mich.
Strong, Carlisle & Hammond Co., Cleveland

TRAPS, RADIATOR
(See Valves, Radiator Return Line)

TRAPS, STEAM
American District Steam Co., No. Tonawanda, N. Y.
Anderson Co., The V. D., Cleveland, O.
Armstrong Machine Works, Three Rivers, Mich.
Barnes & Jones, Jamaica Plain, Massachusetts
Crane Co., Chicago, Ill.
Hoffman Specialty Co., Waterbury, Conn.
Illinois Engineering Co., Chicago
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Powers Regulator Co., Chicago
Sarco Co., Inc., New York City
Strong, Carlisle & Hammond Co., Cleveland
Trane Co., The, La Crosse, Wis.
Warren Webster & Co., Camden, N. J.

TRAPS, VACUUM
Armstrong Machine Works, Three Rivers, Mich.
Barnes & Jones, Jamaica Plain, Massachusetts
Crane Co., Chicago, Ill.
Illinois Engineering Co., Chicago
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Sarco Co., Inc., New York City
Strong, Carlisle & Hammond Co., Cleveland
Trane Co., The, La Crosse, Wis.
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TUBE COUPLINGS
(See Couplings, Tube)

TUBES, BOILER
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Reading Iron Co., Reading, Pa.
Roessing Mfg. Co., Sharpsburg, Pa.

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Bush Mfg. Co., Hartford, Conn.

TUBING, ALUMINUM, FABRICATED
Bush Mfg. Co., Hartford, Conn.

TUBING, BRASS AND COPPER
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Crane Co., Chicago, Ill.

TUBING BRASS AND COPPER, FABRICATED
Bush Mfg. Co., Hartford, Conn.

TUBING, STEEL, FINNED
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TURBO BLOWERS
(See Blowers, Turbo)

UNIONS
Dart Mfg. Co., E. M., Providence, R. I.

UNIT HEATERS
(See Heaters, Unit)

UNIT VENTILATORS
(See Ventilators, Unit)

VACUUM CLEANING APPARATUS
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VALVE RESEATING MACHINES
(See Machines)

VALVES, AIR LINE
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Kennedy Valve Mfg. Co., Elmira, N. Y.

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Crane Co., Chicago, Ill.
Kennedy Valve Mfg. Co., Elmira, N. Y.

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Grinnell Co., Inc., Providence, R. I.
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Davis Regulator Co., Chicago
Illinois Engineering Co., Chicago
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Davis Regulator Co., Chicago
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Davis Regulator Co., Chicago

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Illinois Engineering Co., Chicago
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Mason Regulator Co., Boston
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Crane Co., Chicago, Ill.
Davis Regulator Co., Chicago
Illinois Engineering Co., Chicago
Kennedy Valve Mfg. Co., Elmira, N. Y.

VALVES, FLOAT, AMMONIA
Kennedy Valve Mfg. Co., Elmira, N. Y.

VALVES, FUEL OIL
Crane Co., Chicago, Ill.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.

VALVES, GAS REGULATING
Crane Co., Chicago, Ill.
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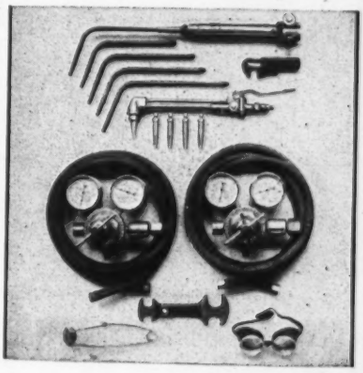

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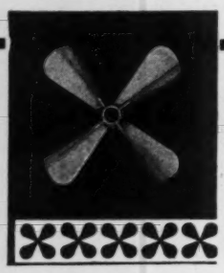

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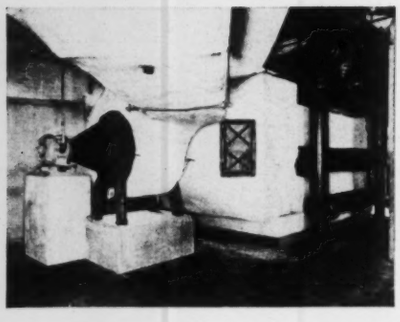

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Scott Valve Mfg. Co., Detroit
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Crane Co., Chicago, Ill.
Illinois Engineering Co., Chicago
Kennedy Valve Mfg. Co., Elmira, N. Y.
Linde Air Products Co., New York
Mason Regulator Co., Boston
Powers Regulator Co., Chicago
Strong, Carlisle & Hammond Co., Cleveland

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American District Steam Co., No. Tonawanda, N. Y.
American Radiator Co., New York
Barnes & Jones, Jamaica Plain, Massachusetts
Crane Co., Chicago, Ill.
Hoffman Specialty Co., Waterbury, Connecticut
Illinois Engineering Co., Chicago
Kennedy Valve Mfg. Co., Elmira, N. Y.
Trane Co., The, La Crosse, Wis.
Warren Webster & Co., Camden, N. J.

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American Radiator Co., New York
Crane Co., Chicago, Ill.
Hoffman Specialty Co., Waterbury, Connecticut
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Crane Co., Chicago, Ill.
Hoffman Specialty Co., Waterbury, Connecticut
Illinois Engineering Co., Chicago
Kennedy Valve Mfg. Co., Elmira, N. Y.
Sarco Co., Inc., New York City
Strong, Carlisle & Hammond Co., Cleveland
Trane Co., The, La Crosse, Wis.
Warren Webster & Co., Camden, N. J.

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American Radiator Co., New York
Crane Co., Chicago, Ill.
Illinois Engineering Co., Chicago
Kennedy Valve Mfg. Co., Elmira, N. Y.
Mason Regulator Co., Boston
Scott Valve Mfg. Co., Detroit

VALVES, SAFETY
Crane Co., Chicago
Kennedy Valve Mfg. Co., Elmira, N. Y.
Scott Valve Mfg. Co., Detroit

VALVES, SOLENOID
General Electric Co., Schenectady

VALVES, STOP AND CHECK
(See Valves, Non-Return)

VALVES, THREE AND FOURWAY
Crane Co., Chicago, Ill.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Nicholson & Co., W. H., Wilkes-Barre, Pa.

VALVES, THROTTLE
Kennedy Valve Mfg. Co., Elmira, N. Y.
Reading-Pratt & Cady Co., Inc., Bridgeport, Conn.
Strong, Carlisle & Hammond Co., Cleveland

VALVES, VACUUM BREAKING
Kennedy Valve Mfg. Co., Elmira, N. Y.
Scott Valve Mfg. Co., Detroit
Skidmore Corp., St. Joseph, Mich.

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VENTILATORS, MUSHROOM
Clarage Fan Co., Kalamazoo, Mich.
Nichols Products Corp., Detroit

VENTILATORS, ROOF
Clarage Fan Co., Kalamazoo, Mich.
Wing Mfg. Co., L. J., New York

VENTILATORS, UNIT
Diehl Mfg. Co., Elizabethport, N. J.
Trane Co., The, La Crosse, Wis.
Wing Mfg. Co., L. J., New York

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Hoffman Specialty Co., Waterbury, Connecticut
Sarco Co., Inc., New York
Trane Co., The, La Crosse, Wis.

VENTS, TRAP, STEAM
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Barnes & Jones, Jamaica Plain, Massachusetts
Hoffman Specialty Co., Waterbury, Connecticut
Sarco Co., Inc., New York
Trane Co., The, La Crosse, Wis.
Warren Webster & Co., Camden, N. J.

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Carrier Engineering Corp., Newark, N. J.
Maryland Air Conditioning Corp., Baltimore, Md.
Nichols Products Corp., Detroit

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Linde Air Products Co., New York

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Linde Air Products Co., New York

WELDING ROD
Air Reduction Sales Co., New York
Linde Air Products Co., New York

WHISTLES
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WIRE, WELDING
Air Reduction Sales Co., New York
Linde Air Products Co., New York

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The Factors in Air Conditioning for Human Comfort.
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Heating and Humidifying Art Museums, by Samuel R. Lewis.
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Air Conditioning for Homes—Humidification, by S. M. Anderson.
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Comments on method used by Brooklyn Union Gas Company applied to underground industrial piping; photographs used to check parts of reseating machine. 2 i.

How Harvard Heats a Hundred Halls, by G. K. Saurwein.
No. 5. May, 1931. *p.* 387.
Early methods used; steam distributed to buildings from electric company plant through well-planned system of tunnels, with hot water converters in building basements; the tunnels; returning condensate saves 10 per cent; distributing heating charge; insulation; plan of tunnels and buildings. 6 i.

Turbine Cuts Steam Waste in Heating and Power Plant, by D. D. Kimball.
No. 12. December, 1931. *p.* 996.
Development of central heating and power plant for Berea College, Berea, Kentucky; first plant installed in 1900; equipment; service extended in 1909; remote buildings supplied with 40-50 lb. steam; plant sells power; new boilers installed in 1923 and 1927; power demands caused exhaust steam waste; installation of turbine conserves exhaust steam; auxiliary equipment; plant has high rating for efficient operation; chief engineer and consulting engineer. 3 i.

Paris District Heating System Handicapped, by A. C. Coonradt.
No. 6. June, 1931. *p.* 535.
("Open for Discussion"); comments on "Steam Piping for New District Heating System in Paris" by Phillippe Schereschewsky, November, 1930, issue; load density; bled steam; advantages of district heating; J. H. Walker comments on by-product generation of power. 1 i.

Over a Billion Lb. of Steam per Year.
No. 7. July, 1931. *p.* 570.
Grand Central Terminal zone in New York City supplied with steam for heating and power by New York Steam Corp.; metering; pump room; steam lines. 6 i.

Electric Boilers Flatten Hydro System Load Curve—Steam Used for District Heating.
No. 7. July, 1931. *p.* 579.
(Some Reports on Research); interview with J. G. Glassco,

manager, Hydro Central Heat, Winnipeg; supplies downtown district; water tube boilers; electric boilers improve load factor; steam produced; steam main; rates for steam. 2 i.

District Heating System Supplements Municipal Power Plant, by Ludwig Wahl, Paul Reschke and F. E. Giesecke.
No. 11. *November,* 1931. *p.* 904.
Hot water district heating system in Dresden, Germany; development; heating system improves over-all efficiency of municipal power plant; features of the system; two flow lines, one return line; concrete pipe conduits; static head; heat exchangers; underground piping; connections to buildings; connecting new customers; distribution chamber in power house; condensate; heat demand; total heat delivered; production of steam and electricity; hospitals good customers. 9 i.

Heat Accumulator Stores Hot and Cold Water.
No. 12. *December,* 1931. *p.* 1012.
Large tank stores heat to supply peak demands of central hot water heating system in Hamburg, Germany; dimensions; capacity; outlets and inlets; electric welded.

Two Supply Mains Used for Central Hot Water Heating, by S. R. Lewis.
No. 6. *June,* 1931. *p.* 464.
Two supply mains at different temperatures used for central hot water heating in Sweden; use of welded steel section radiators; interview with Prof. Gille of Stockholm.

Heating—Hot Water, Steam, Vacuum, Vapor, Unit Heaters

Use of Condensation Meters in Heating Systems, by B. M. Conaty.
No. 2. *February,* 1931. *p.* 130.
Use of meters in industrial plants; dumping type; rotary; use of surge tank; capacity of receiver necessary; two meters often desirable; economizer arrangement; accuracy of meters; attention necessary; piping of the meters; application to vacuum and gravity systems. 3 i.

$1,739 Reduction in Annual Heating Cost Indicated by Consulting Engineer's Study, by Samuel R. Lewis.
No. 12. *December,* 1931. *p.* 1013.
Need for a thorough study of heating costs; cost of heating a typical foundry with pipe coils and salamanders; no heat regulation; heat loss, temperature gradient, coefficients, stack effect, infiltration, tabulation; estimated heat loss if unit heaters were installed; initial cost of units; table of estimated savings. 4 i.

How a Vacuum Return Heating System was Inspected and Improved, by W. H. Wilson.
No. 6. *June,* 1931. *p.* 538.
(Practical Piping Problems); thorough test made; traps tested; stop cock worn; vacuum gages an aid; a handy radiator tester. 3 i.

Low Vacuum on Heating Return Lines.
No. 5. *May,* 1931. *p.* 408.
Causes of low vacuum on heating return lines.

Plate Glass Windows.
No. 6. *June,* 1931. *p.* 540.
Use of radiator shield between radiators and plate glass windows recommended by insurance companies.

Heating and Air Conditioning the Carbide and Carbon Building, by A. McCawley.
No. 1. *January,* 1931. *p.* 37.
General description of Chicago office building; piping over 2½-in. welded; vacuum heating system zoned; control of temperatures and pressures; air supply humidified and filtered; ducts; dirt trap bushing on radiators. 7 i.

Coal and Ash Handling for Boilers Fifty Feet Under Chicago River, by T. H. Monaghan.
No. 2. *February,* 1931. *p.* 116.
Merchandise Mart, Chicago; boilers; boiler and pump rooms underground; coal bunkers and conveyors; stokers; handling the coal; weigh larry; ashes removed through tunnel. 7 i.

Boilers Installed in Office Building Pent-House.
No. 2. *February,* 1931. *p.* 112.
Low pressure boilers for heating and domestic hot water located on roof of Eastern Outfitting Co. office building in Los Angeles, Calif.; burn oil or gas; piping from tank under sidewalk; oil pumps; atomizing air; the gas system. 2 i.

Combination Steam and Hot Water Systems Heat Court House and Jail, by H. A. Durr.
No. 3. *March,* 1931. *p.* 214.
Cook County, Ill., criminal court house and jail; cell buildings; heating systems; steam purchased; heat converters; hot water heating system; feeding radiators above overhead main; steam heating system; ventilation; ventilating record vault; gages and control. 6 i.

All-Steel-and-Glass Building Proves Economical to Heat, by A. I. Snow.
No. 10. *October,* 1931. *p.* 848.
Office of Worcester Pressed Steel Co., Worcester, Mass.; forced hot water system used; location of radiation; control of temperatures; turbine and motor drive circulating pump; exhaust steam heats water; fuel used. 2 i.

Unit Heaters Save Floor Space in Skyscraper Entrance, by Henry G. Schaefer.
No. 10. *October,* 1931. *p.* 862.
Unit heaters over revolving door heat vestibule; capacity; control. 2 i.

Records Show How to Save Heating Steam.
No. 10. *October,* 1931. *p.* 821.
Record system used by Building Managers' Association of Chicago; the charts and how to use them; graphical records; lowest possible unit steam consumption can be obtained; applicable to all types of buildings. 4 i.

Lack of Inspection Causes Steam Waste, by W. T. Jones.
No. 12. *December,* 1931. *p.* 1020.
Lack of inspection of radiator traps results in waste of steam; vent from vacuum pump blowing steam; return main; cooling leg; trap plugged with dirt.

How to Design the Piping for a Combined Forced and Gravity Circulation Reversed Return Hot Water Heating System, by F. E. Giesecke.
No. 6. *June,* 1931. *p.* 458.
System in 4-story dormitory at Texas A. & M. college; identifying radiators; the problem; proper procedure; riser connections; use of orifices; tolerances; balancing circuits; system checked in operation. 8 i.

Method of Heating and Ventilating a Small School, by Samuel R. Lewis.
No. 10. *October,* 1931. *p.* 844.
Twelve-classroom elementary Burroughs school in Toledo, Ohio; construction of building; radiators above air supply openings; steel plates form duct bottoms; air distribution; auditorium-gymnasium; addition of stokers will increase boiler capacity; steam at or below atmospheric pressure; control of steam; radiators in toilet rooms; location of thermostats; air intakes; total and unit costs of the plant. 6 i.

The New Hotel Waldorf-Astoria—A Description of the Heating and Piping Systems, by the Staff of Clyde R. Place.
No. 4. *April,* 1931. *p.* 275. *Also see p.* 369, *May,* 1931.
General description of New York hotel; plan of girder space; plan of sub-basement; importance of uninterrupted service; steam and electricity from outside; two-pipe vacuum system; risers and mains; returns and drips; intermediate pressure steam; steam header; vacuum cleaner piping. 8 i.

Heating—Warm Air

Large Space Warm Air Heating, by O. W. Kothe.
No. 6. *June,* 1931. *p.* 479.
Heating an industrial plant; performance tests; fans; heating a church; general comments. 6 i.

Warm Air Heating Plant Protects Sugar in Storage.
No. 9. *September,* 1931. *p.* 761.
Warm air heating plant at Gramercy, La., refinery of Colonial Sugars Company prevents absorption of moisture in refined sugar in storage; size of warehouses; natural gas burned. 5 i.

Warm Air System Conditions Lodge Hall, by Platte Overton.
No. 8. *August,* 1931. *p.* 652.
Application of direct fired, hot blast system in Masonic Temple at Burlington, Wis.; oil-fired heater; air recirculated; inlets; deep well water used in air washer for summer cooling; how the system was designed; complete computations; humidity control; circular equivalents of rectangular ducts; friction in ducts; temperature control; diffusion of air; heater size; fan and motor; design of duct system; velocities. 7 i.

Eight Gas-Fired Units Heat Large Armory, by Louis L. Narowetz, Jr., and R. M. Moffitt.
No. 11. *November,* 1931. *p.* 937.
Description of 124th field artillery armory in Chicago; capacity, temperature rise, air velocity, etc., of units; recirculation ducts; figuring heat loss; products of combustion; temperature maintained. 3 i.

Trunk Ducts for Warm Air Heating, by O. W. Kothe.
No. 7. *July,* 1931. *p.* 578.
("Open for Discussion"); comments on "Trunk Ducts for the Fan Blast System of Warm Air Heating," p. 923, November, 1930, issue; turbulence; double duct; plaster and brick lining; operation of fans.

Trunk Ducts for Warm Air Heating Systems, by James J. Finan.
No. 12. *December,* 1931. *p.* 1064.
(Open for Discussion); comments on "Trunk Ducts for the Fan Blast System of Warm Air Heating," by Platte Overton, November, 1930, issue. 2 i.

Piping—General

A Diagram for Gas Flow in Pipes, by Leonard L. Hohl.
No. 5. *May,* 1931. *p.* 393.
Use of Fanning formula in chart form; a steam flow problem; how to use the chart; pressure drop with butane flowing; viscosity of steam; discussion by John C. Reed, Edgar E. Ambrosius, and R. E. Gould on value of consistent units and limitations of the chart. 2 i.

Piping Used to Unload Finely-Ground Products.
No. 1. *January,* 1931. *p.* 32.
Cement piped from ship for building foundations (Merchandise Mart, Chicago); size of lines and pumps; amount of air. 2 i.

Largest Cast Iron Pipe.
No. 3. *March,* 1931. *p.* 213.
Telephone subway under Harlem River, New York; placing the pipe. 1 i.

Simplified Practice for Wrought Pipe and Fittings.
No. 1. *January,* 1931. *p.* 19.
Standard reaffirmed by standing committee of industry; degree of adherence.

A. S. T. M. Committee on Cast-Iron Pipe.
No. 6. *June,* 1931. *p.* 539.
Work of sectional committee during 1930 (from *A. S. T. M. Bulletin.*)

A. S. T. M. Committee Approves Piping Standards.
No. 10. *October,* 1931. *p.* 820.
Tentative standards on electric-fusion-welded, electric-resistance-welded, forge-welded, and lock-bar steel pipe and riveted steel and wrought iron pipe approved.

Some Odd Uses for Lead Pipe, by William Anderson.
No. 7. *July,* 1931. *p.* 635.
Use of lead as gasket; uses of lead filings.

How to Install and Care for Gages of the Bourdon Tube Type, by John A. Masek.
No. 9. *September,* 1931. *p.* 727.
Types; selecting size; selecting style; pressure range; single spring; vacuum and compound; double spring; effect of freezing; effect of heat; inlets and cocks; piping for gages; correcting for water column; the gage board; testing; overpressure; why a gage may not register; causes of pointer being away from zero; leaks inside a gage. 14 i.

Recent Article on Bourdon Tube Gages Discussed, by J. O. Tragard.
No. 11. *November,* 1931. *p.* 939.
(Open for Discussion); comments on "How to Install and Care for Gages of the Bourdon Tube Type," September, 1931, issue; standard sizes; selecting size; steel springs; self-draining; heat of steam; water column; use of maximum hand; author replies to comments. 1 i.

Suitable Metering Devices Aid Economical Operation; by W. H. Wilson.
No. 5. *May,* 1931. *p.* 451.
(Practical Piping Problems); use of flow meters; checking compressed air lines; checking vacuum; portable meters; piping connections; water meter testing connections. 2 i.

Undetected Leaks Waste Money, by W. H. Wilson.
No. 7. *July,* 1931. *p.* 633.
(Practical Piping Problems); example of leaks found in industrial piping lines; points to watch; importance of stopping them. 3 i.

Care of Valve Stems—Opening Stuck Valves, by W. H. Wilson.
No. 8. *August,* 1931. *p.* 723.
(Practical Piping Problems); care of valves; how to open a valve which is stuck; opening a water valve; care of valves before installation. 1 i.

Uses of Check Valves in Industrial Piping Systems, by W. H. Wilson.
No. 12. *December,* 1931. *p.* 1066.
(Practical Piping Problems); use on pump discharge piping; on paint spraying equipment; on a hoist; on railway car brake testing lines. 3 i.

Piping Maintenance in Freezing Weather, by W. H. Wilson.
No. 10. *October,* 1931. *p.* 893.
(Practical Piping Problems); attention to check valves; gate valve damaged; anti-freeze solution; shut-off valves must be tight; watch these points. 4 i.

X-Ray Inspection of Welded Pipes and Pressure Equipment, by Herbert R. Isenburger.
No. 4. *April,* 1931. *p.* 304.
Installation for routine examination; use and value of X-rays; views showing porous weld, slag and porosity; cavity; sound gas weld; diagram of set-up for investigating welded tubing. 6 i.

How Welds Are Tested.
No. 12. *December,* 1931. *p.* 1021.
Description of methods of testing welds as given in a paper presented at the annual meeting of the *International Acetylene Association;* visual examiniation; hammer and anvil nick-break test; free bend test for ductility; tension test; hardness tests; specific gravity; stethoscope test; invisible ray tests; compression and drift tests; hydrostatic tests. 4 i.

Welded Piping, by G. K. Saurwein.
No. 6. *June,* 1931. *p.* 536.
(Open for Discussion); comments on "Higher Pressures and Temperatures as They Affect the Design, Installation, and Maintenance of Piping," by J. J. Harman, Dec., 1930, to Feb., 1931, issues; power plant piping welded; changes easily made.

Piping—Air

Piping Analysis Assures Minimum Compressed Air Cost, by A. W. Loomis.
No. 11. *November,* 1931. *p.* 899.
How the piping in a large mine was modernized; determining required capacity; laying out underground piping; computing the pipe sizes; pressure drop; choice of size an economic proposition; pressure for compressors; cost of air and pipe installed; installing compressors. 5 i.

Proper Practices to Observe for Vacuum Cleaner Piping Systems, by Lester C. Smith.
No. 10. *October,* 1931. *p.* 852.
Central vacuum cleaning systems; ratings—sweeper capacity; sweeper chart; designing the piping; charts available; judgment needed; right and wrong arrangements of piping; specifications for cleaning systems; vacuum in inches of mercury lost in pipes 100 ft. long; operation and maintenance. 9 i.

Installing Industrial Air Piping, by W. H. Wilson.
No. 11. *November,* 1931. *p.* 985.
(Practical Piping Problems); troubles with air piping; use of separators; anti-sweat insulation; alcohol clears ice from line; piping the receiver; moisture; points to consider in installation. 2 i.

Piping—Hydraulic

How to Figure Amount of Water Used by Hydraulic Presses, by F. G. Schranz and W. L. DeLaney.
No. 2. *February,* 1931. *p.* 135.
The cycle; returning the ram; types of presses; auxiliary rams; two-pressure system; amount of water; theoretical power; allowance for leakage. 2 i.

Methods of Supplying Fluid to Hydraulic Press Installations, by F. G. Schranz and W. L. DeLaney.
No. 12. *December,* 1931. *p.* 1003.
Importance of fluid supply; the accumulator; intensifiers; determining diameter of high pressure ram; types of pumps used; single pressure systems; multiple pressure systems; characteristics and uses of each. 2 i.

Hydraulic Press Operation, by Mark W. Roe.
No. 4. *April,* 1931. *p.* 360.
(Discussion of "How to Figure Amount of Water Used by Hydraulic Presses," February, 1931, issue); clamp on ram when idle stroke is too great; multiple-pressure operation; accumulator.

High Pressure Hydraulic Systems, by John H. Ruckman.
No. 5. *May,* 1931. *p.* 382.
Trend toward high pressures; power and pressure; central stations; large plant broken up in units; control valves; leakage; shut-downs; accidents; damage to piping inside and outside plant; system of maintenance needed; inspection; records; fluid must be pure. 6 i.

Linseed Oil Manufacturing Process Depends on an Extensive Piping System, by J. Gordon Fletcher.
No. 8. *August,* 1931. *p.* 668.
Manufacturing process; linseed oil as hydraulic medium; the pumps; presses operated in groups; timing; piping; lines sectionalized; clean lines essential; make-up oil; packing. 2 i.

Piping Arrangements in a Gate Lifter, by C. G. Moon.
No. 12. *December,* 1931. *p.* 1025.
Function of lock gate lifter; piping; ballast tanks; pumps; equalizing system; method of operation. 3 i.

How to Keep Hydraulic Equipment from Freezing, by W. H. Wilson.
No. 1. *January,* 1931. *p.* 96.
(Practical Piping Problems); steam heating an hydraulic press; the piping necessary; bulk-head in pipe tunnel affords protection; use flanges and unions liberally. 1 i.

Hydraulic Piping Damaged by Freezing, by W. H. Wilson.
No. 2. *February,* 1931. *p.* 187.
(Practical Piping Problems); loosen packing box gland bolts on hydraulic press cylinders, accumulators, and similar equipment to prevent damage from freezing; how one press was damaged; steam forging hammers. 1 i.

Piping—Oil and Gas

Piping Oil for Industrial Processes, by Paul R. Unger and Kalman Steiner.
No. 1. *January,* 1931. *p.* 9.
Plant of Indestro Manufacturing Co., Chicago; oil storage; inside and outside piping; strainers; pumping; choice of a piping system; air piping; pipe sizes; relation between f and Dus/Z; sample calculations. 6 i.

A. G. A. Joint Research.
No. 2. *February,* 1931. *p.* 185.
(Some Reports on Research); interview with R. M. Conner on gas line research at American Gas Association laboratory in Cleveland; gas leakage expensive; universities cooperate; old joints tested; methods of repairing studied; leak clamps; effect of temperature changes. 1 i.

How Oxygen and Acetylene Are Piped in a Manufacturing Plant, by W. A. Slack.
No. 5. *May,* 1931. *p.* 407.
Plant of Naylor Pipe Co., Chicago; gas house; acetylene line; disposal of sludge; carbide storage; oxygen manifold room and piping; flash-backs; importance of clean pipe. 4 i.

The New 950-Mile Natural Gas Pipe Line from Texas to Chicago, Ill.
No. 10. *October,* 1931. *p.* 842.
Views along the line; kind of pipe; rate classifications. 10 i.

Reclaiming Arrangement for Waste Oil, by W. H. Wilson.
No. 9. *September,* 1931. *p.* 809.
(Practical Piping Problems); arrangement for collecting and reclaiming waste oil leaking from transmission lines in industrial plants; construction of tank. 1 i.

Fabrication of a Pipe Special.
No. 12. *December,* 1931. *p.* 1016.
Welded pipe special for a natural gas line; reducer at one end; formula for number of cuts; saddle plates welded on. 1 i.

Piping—Refrigeration

Factors Affecting the Design of Evaporators, by Herman Vetter.
No. 1. *January,* 1931. *p.* 40.
Properties of water, ammonia, carbon dioxide; principle of evaporator; flash type; direct expansion; liquid feed at top; flooded type; indicating liquid level; vertical tubes; shell and tube cooler; baudelot cooler; surface required; heat transfer coefficients; factors affecting design; influence of brine velocity; gas velocities; comparison with boiler. 13 i.

The Design of Evaporators, by Edgar E. Ambrosius and John C. Reed.
No. 4. *April,* 1931. *p.* 317.
(Discussion of "Factors Affecting the Design of Evaporators," January, 1931, issue); amount of liquid flashing to vapor; velocity of suction line; heat transfer coefficients; some additional factors to consider. 6 i.

Piping Improvements Reduce Cost of Pumping, by Herman Vetter.
No. 10. *October,* 1931. *p.* 835.
Condenser water circulating system in a manufacturing plant revised to save power; loss in original and new suction lines, with detailed computations; test of new piping; question of purchasing a new pump; test run with new pump; comparison of old and new systems; reduction in power cost. 3 i.

Proper Care of Brine Aids Prevention of Corrosion, by R. C. Doremus.
No. 5. *May,* 1931. *p.* 372.
Research in corrosion prevention of refrigerating equipment; brine strength; electrolysis; acidity; alkalinity; tests; color scale for bromthymol blue, thymol blue, phenol red, cresole red, phenolphthalein; sodium dichromate; disodium phosphate; zinc dust; cost of corrosion retarders; decrease of concentration of sodium dichromate in calcium chloride brine; curves showing relative corrosion rates for iron and steel in various brines. 7 i.

Phenolphthalein as an Indicator.
No. 3. *March,* 1931. *p.* 273.
Use of phenolphthalein for indicating acidity or alkalinity of brine solutions; the solution; its color for pH values.

pH Method of Determining Acidity and Alkalinity.
No. 2. *February,* 1931. *p.* 134.
Explanation of pH values and their determination; precautions to observe when using sodium dichromate in brine solutions.

Piping—Steam (Including Steam for Process Work and Process Piping)

Handling Viscous Materials, by Lee P. Hynes.
No. 5. May, 1931. *p.* 363.
Conveying oils, greases, pitch, tar, waxes, syrups, etc., in piping; drop in elbows; relation of temperature and viscosity of oils; velocity; choosing the pump; steam jacketed and electrically heated pipe, pumps, etc.; heating jacketed vessels with oil; thermal storage of heater; typical job; filling system with oil; starting; contamination; control; insulation. 16 i.

Process Industries Piping, by C. L. Mantell.
No. 7. July, 1931. *p.* 635.
Extent of chemical process industries piping; substances piped; materials; factors to consider.

Higher Pressures and Temperatures as They Affect the Design, Installation and Maintenance of Piping, by J. J. Harman.
No. 1. January, 1931. *p.* 20.
Power required to operate valves; types of valves; factors affecting gate valve operation; unbalanced pressure on bottom of stem; increased cost of high pressure piping; effect of high temperature on design; range of temperatures; creep tests; safe stress curve for 0.30 carbon steel; equicohesive temperature; materials; foundry technique; volume of fluid in hydraulic and steam systems at various pressures; welding; standardization; care in handling valves. 18 i.

Higher Pressures and Temperatures as They Affect the Design, Installation and Maintenance of Piping, by J. J. Harman.
No. 2. February, 1931. *p.* 106.
Alloys for hign temperature use; valve trim materials and requirements; new developments; cast, forged and welded pressure containers; pipe joints; type; welded piping; gaskets; bolts for flanged joints; general comments on high pressure-high temperature piping. 7 i.

Bending of Curved Pipes, by Sabin Crocker.
No. 5. May, 1931. *p.* 399.
A review and explanation of the theory and its practical applications; flattening theory; effect on stress distribution; safe stresses for curved pipe; temperature and creep; piping for 750 F and over; curves for determining rigidity multiplication factor and stress multiplication factor. 6 i.

Bursting Stress in High Pressure Piping, by Harvey A. Wagner. (Discussion by John J. Harman.)
No. 8. August, 1931. *p.* 658.
Birnie and Clavarino formulas; application of Birnie formula; elastic failure theories (Rankine, St. Venant, and Guest); Army Ordnance Department tests on thick-walled cylinders; closed cylinders with ends attached to walls; use of Barlow formula; when do closed end conditions prevail?; piping work analogous to open end conditions; Lamé formula. 5 i.

Curves Aid in Design of Thick-Walled Tubes and Cylinders, by F. E. Wertheim.
No. 10. October, 1931. *p.* 850.
Formulas for design of thick-walled tubes; curves simplify use of Clavarino formula; example shows use. 2 i.

Development of Clavarino Formula, by Harvey A. Wagner.
No. 11. November, 1931. *p.* 987.
Steps in the development of the Clavarino formula from the general equation to the form $t = r \times C$.

Metallurgical Requirements for High Temperature Steam Piping, by F. W. Martin.
No. 8. August, 1931. *p.* 673.
Development of use of high temperatures; pipe; fittings; valves; studs and nuts; conclusion. 5 i.

Piping for 1,000-Degree Steam, by J. H. Walker.
No. 4. April, 1931. *p.* 283.
Turbine installed at Delray plant of Detroit Edison Co. uses steam at 1,000 F; effect of increased temperature; turbine installation; tensile strength of metals at elevated temperatures; creep stress for steels; preliminary experiments; piping materials; fittings; piping design; provisions for expansion; center-pressure valve; joints; insulation. 5 i.

Designing High Temperature Steam Piping, by Arthur McCutchan.
No. 10. October, 1931. *p.* 825.
(Part I—Flexibility of 1,000 F line); lay-out of high temperature piping at Delray; reactions determined by graphoanalytical method; method of introducing flexibility at Issy Les Moulineaux Station of Paris Electric Co.; coefficient of expansion of 18 per cent chromium-8 per cent nickel piping used at Delray; design conditions; expansion; linear expansion of austenitic chrome-nickel and medium carbon steels; flexural rigidity of line; reduction of modulus of elasticity with increase in temperature; flexibility of pipe, valve, and fittings; method for one force described; bending moments; reacting forces; assumptions err on safe side; shear stress due to torsional moment. 9 i.

Designing High Temperature Steam Piping, by Arthur McCutchan.
No. 11. November, 1931. *p.* 918.
(Part II—Pipe joints for 1,000 F service); flexibility of *A. S. A.* flanged joints; effect of temperature difference on bolted joints; design of heavy flanged joint; creep characteristics of 10-in., 600-lb. flanges; spring absorbs creep; effect on life of joint; effect of spring on bolt stress due to temperature difference; bolts with full shanks and bolts threaded entire length; formulas for stress; gasket compression on side of joint which has pressure decreased by bending moment; load vs. change in length; reduction in modulus of elasticity with increase in temperature; stress vs. creep rate at 1,000 F; conclusions. 8 i.

Selecting Sterilizers, by Rollo E. Gilmore.
No. 1. January, 1931. *p.* 33.
Use; steam pressures; dressing sterilizers and autoclaves; accessories; sizes of cylindrical pressure sterilizers; built-in sterilizers; drum sterilization; steam and electric consumption. 2 i.

Selecting Sterilizers, by Rollo E. Gilmore.
No. 2. February, 1931. *p.* 119.
Disinfectors; air must be eliminated; steam consumption; instrument sterilizers; need for steam separator; sizes; steam and electric consumption; roughing-in dimensions; piping; utensil sterilizers; milk and bottle pasteurizers; bed pan washers; recessed construction; water sterilizers; steam and electric consumption; recommended sizes. 6 i.

Selecting Sterilizers, by Rollo E. Gilmore.
No. 3. March, 1931. *p.* 210.
Central water sterilizers; saline apparatus; water stills; types; operation; stills in conjunction with pressure type sterilizers; storage tanks for distilled water; steam, gas or electric consumption; non-pressure type sterilizers; diagrams of electric and gas heated water stills. 5 i.

Selecting Sterilizers, by Rollo E. Gilmore.
No. 4. April, 1931. *p.* 320.
Hot air sterilizers, blanket warmers, bed pan and solution cabinets; dimensions; sterilizer connections and service; vents; air brake, waste and funnels to prevent contamination of distilled water; steam demand; sterilizer tests. 2 i.

Piping an Industrial High Pressure Plant—Electric Power and Process Steam Loads Balanced, by J. V. Edeskuty.
No. 3. March, 1931. *p.* 189.
Waldorf Paper Products Co. plant, St. Paul, Minn.; plant remodeled; cost; division of cost; heat balance; high pressure piping, design, tests, flow in, expansion and supports; steam purifiers; insulation; boiler feed, blow-off, low pressure piping; identification; white water heaters. 10 i.

Piping an Industrial High Pressure Plant—Electric Power and Process Steam Loads Balanced, by J. V. Edeskuty.
No. 4. April, 1931. *p.* 293.
Description, operation, control, estimating value, calculating capacity, valves, etc., for steam accumulator installed at Waldorf Paper Products Co.; steam flow diagram. 2 i.

High Pressure Steam and the Modern Industrial Plant, by E. H. Barry.
No. 7. July, 1931. *p.* 547.
Trend toward high pressure; opportunities for economies where process steam is used; by-product power; secondary power; reducing cost of power; high pressure steam; reheating; supplying process steam for a typical plant; lay-out; calculations; use of Mollier diagram; demand not constant; allow for future trends; reducing valve and desuperheater. 4 i.

Process Steam and Power, by S. H. Hemenway.
No. 10. October, 1931. *p.* 858.
(Open for Discussion); comments on "High Pressure Steam and the Modern Industrial Plant," by E. H. Barry; use of bleeder turbines; savings made; proper use and control of process steam; an oil refinery installation. 1 i.

Oil in Exhaust Steam Reduces Heat Transfer, by R. P. Tobin.
No. 12. December, 1931. *p.* 1028.
Heat transfer in a radiator; temperature gradient; rate of heat transfer; film resistance; oily deposit or scale; prevention of contamination; careful oil selection for prime movers necessary; method of application important; direct application; simple injection; injection with atomizer; removing oil from exhaust steam. 5 i.

Piping High, Intermediate and Low Pressure Steam Economically, by H. L. Colby and Francis A. Westbrook.
No. 11. November, 1931. *p.* 933.
New boiler plant for Mason Regulator Co., Boston, Mass., supplies 400-lb. steam for testing, 150-lb. steam for process and steam for heating; piping lay-out; arrangement of reducing valves; equipment used; boiler feed; by-pass for feed water heaters; oil burner and control; steam and electric oil preheaters; piping materials. 5 i.

Piping Plant Atkinson, by E. C. Gaston.
No. 6. June, 1931. *p.* 465.
60,000 kw. plant of Georgia Power Co.; importance of piping; controlling factor in design; principal equipment; three piping classes; materials; joints; heat balance diagram; high pressure bolts of special steel; flange finish and gaskets; valves and fittings; piping gallery; responsibility of piping contractor; provision for future units; no by-passes around feedwater regulating valves; cast iron circulating water discharge line; analysis of stresses in piping; study of insulation; insulation used; canvas jackets; insulation of hot air ducts; costs of piping per kw. 8 i.

Piping Reliability—of Importance in Power Plant Near Arctic Circle, by R. A. Hanright.
No. 9. September, 1931. *p.* 741.
Power plant for grain elevator of Department of Railways and Canals at Fort Churchill, Canada; boilers, economizers, turbo-generators; steam at 650 F; plan and section of power house; concrete pipe tunnel; cast iron water lines; insulation and support; by-pass from main steam header to 60-lb. line; make-up feed water; handling condensate; reliability essential; plant operates three months per year; diagram of power piping; piping schedule; contractors, engineers, etc. 8 i.

Installing a 3,400-Ft. Overhead Steam Line, by L. C. Winkelhaus.
No. 12. December, 1931. *p.* 999.
4-in. wrought iron welded line for conveying 150-lb. steam for car heating at Chicago & North Western Railway Company's express terminal; estimating needed capacity; pipe sizes used; providing for expansion; supporting the line; details of pipe support towers; pipe covering; bucket traps; testing the line. 11 i.

Canadian Pacific Locomotive Operates on 1,350 Lb. Pressure.
No. 10. October, 1931. *p.* 831.
Brief review of features of "8,000" type. 2 i.

Steam from Contented Reducing Valves, by Henry G. Schaefer.
No. 5. May, 1931. *p.* 397.
Use of two small reducing valves for supplying steam for heating; typical example and method of sizing; diagram showing lay-out; arrangement offers gradual expansion. 1 i.

Flow Through Valves, by M. T. Martin.
No. 7. July, 1931. *p.* 577.
(Open for Discussion); comments on "Sizing Pressure Regulators," p. 416, May, 1930, issue; determining velocity of steam through port; method.

What Size Reducing Valve? by H. P. Adams.
No. 9. September, 1931. p. 767.
(Open for Discussion); what is proper size? need for automatic control; use of thermostatic valves; typical lay-out; velocity through orifice; formula for pounds of steam; capacities of pressure reducing valves (100 lb. to 50 lb. or less); Henry G. Schaefer comments on velocities. 1 i.

Don't Always Condemn the Trap, by T. H. Rea.
No. 9. September, 1931. p. 808.
Diagram of installation in which trap refused to work at low pressures but performed satisfactorily at high; force available to open traps; high steam velocity thought to be the cause; steam superheated—no condensate formed. 1 i.

Shortening an Inaccessible Pipe Coil, by W. H. Wilson.
No. 2. February, 1931. p. 187.
(Practical Piping Problems); coil obstructed by heavy stand; how the coil was shortened by means of cutting torch and welding. 1 i.

The Inside of the Pipe Line, by W. H. Wilson.
No. 3. March, 1931. p. 272.
(Practical Piping Problems); inside condition of piping important; nipple worn by water; pipe thread cut; elbow worn; keeping line in good condition. 2 i.

Joints in New Steam Line Cut, by W. H. Wilson.
No. 8. August, 1931. p. 724.
(Practical Piping Problems); possible reasons for joints in 125-lb. line being cut by steam; remedies. 1 i.

Small Pipe Coils Used to Reduce Steam for Heating.
No. 9. September, 1931. p. 812.
Small-size pipe coils arranged to reduce steam for heating for various parts of an industrial plant and office building; diagrams show how system is installed and operated; method of supplying hot water. 5 i.

Supports and Anchors for Piping—Three Typical Problems, by G. W. Hauck.
No. 5. May, 1931. p. 414.
Connections to turbines and steam driven auxiliaries; anchoring turbine header; exhaust connections; connection from turbine to overhead main; preventing strain on throttle valve. 5 i.

Pipe Supports, by T. M. Dugan.
No. 8. August, 1931. p. 725.
Diagram of commonly used support for overhead steam mains. 1 i.

Installing Box Unions, by W. H. Wilson.
No. 4. April, 1931. p. 361.
(Practical Piping Problems); a right and wrong way to install box unions; typical examples; lip worn away; face union so flow will not strike seating face. 2 i.

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Paper Mill Improves Product Through Piping Changes, by Max W. Benjamin.
No. 7. July, 1931. p. 562.
Port Huron Sulphite and Paper Co. improves screen room white water system; lay-out; provisions for cleaning; copper pipe; joints; installation; make-up water; flow diagram. 2 i.

Piping a Pumping Station, by Orville B. Carlisle and Duane E. Kennedy.
No. 8. August, 1931. p. 642.
Western Avenue pumping station, Chicago; 11-mile tunnel through rock; gate valve in suction piping; water for condensers; header system in pipe vault; sectionalizing and valving headers; control of motor-operated valves; velocities in piping; expansion joints; anchorage; water hammer; reinforcing large fittings; meters; check valve in pump discharge; insulation of pipe; care in installation. 7 i.

Piping System for Power Tube Cooling Water at Radio Station KDKA, by E. M. Sollie.
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Proper Pipe Line Support.
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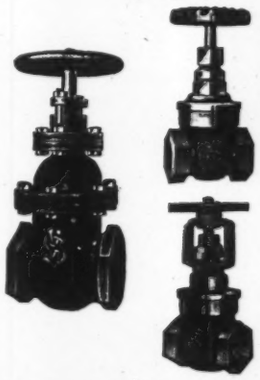

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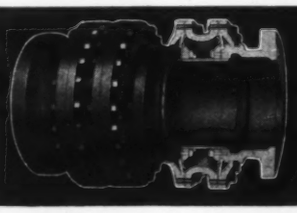

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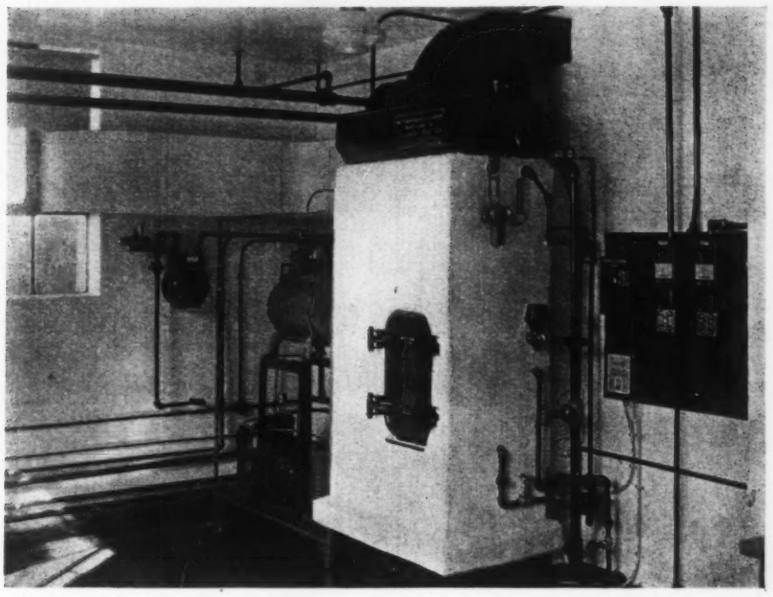

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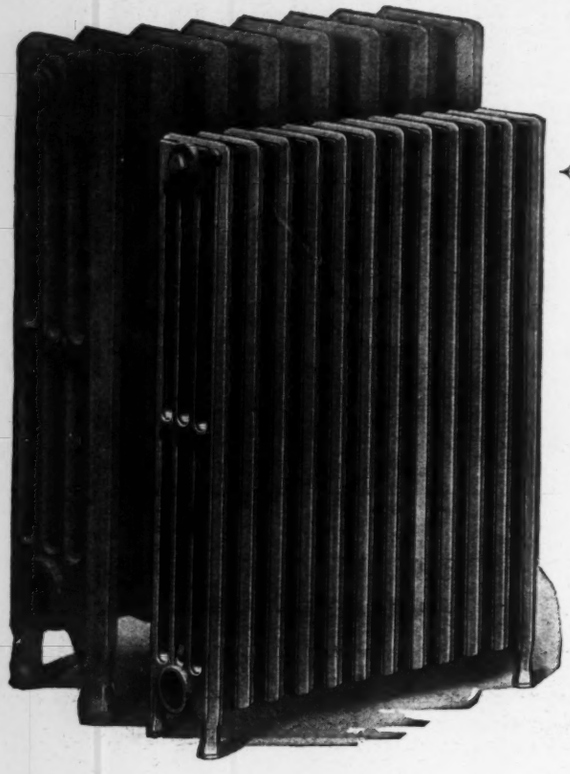

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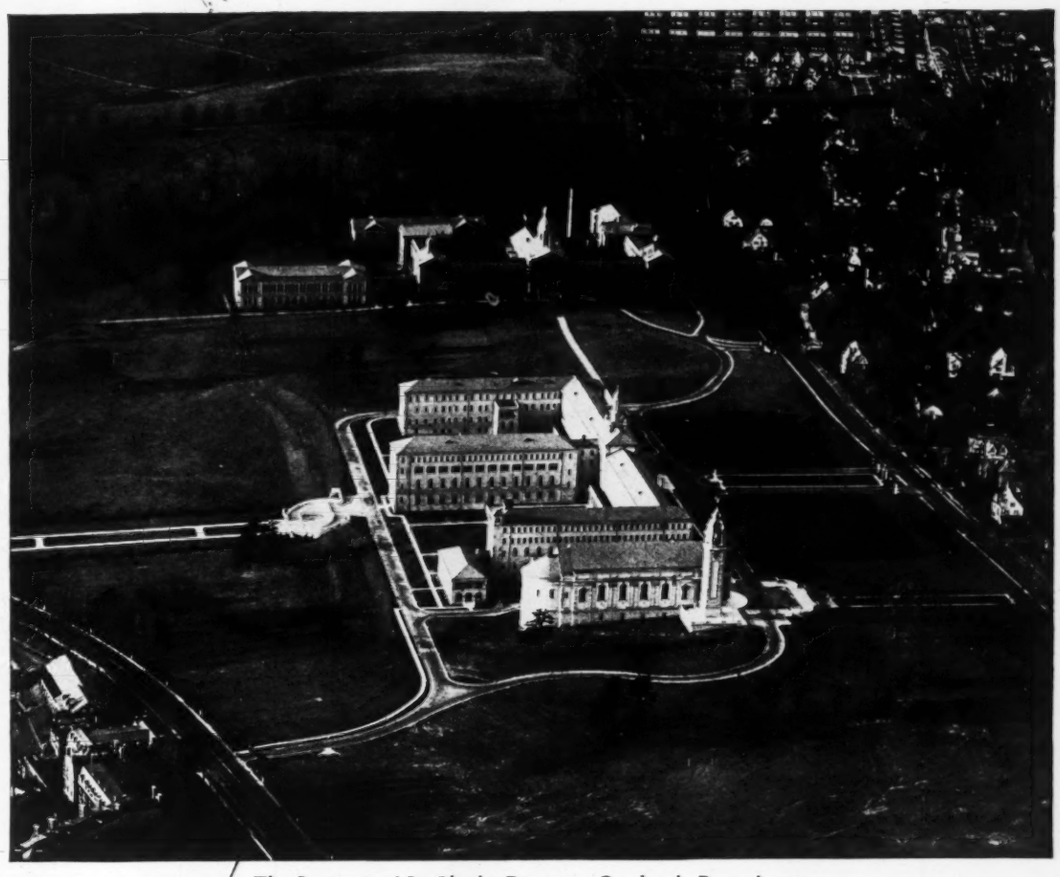

The Seminary of St. Charles Borromeo, Overbrook, Pennsylvania

New Group in foreground:
Paul Monaghan, *Architect*
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Alterations to old group in background:
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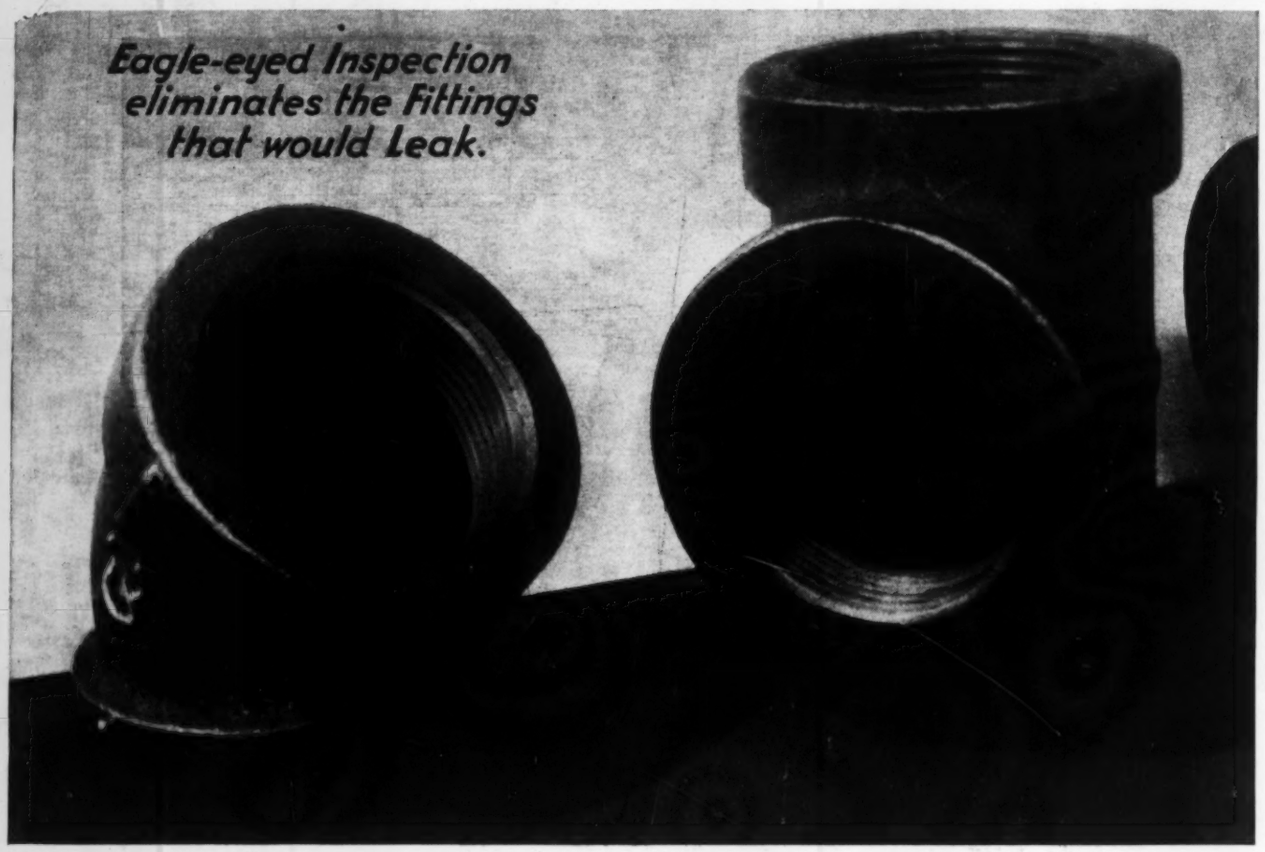

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